R-3825-1B

TECHNICAL MANUAL

OPERATING INSTRUCTIONS

J-2 ROCKET ENGINE

(ROCKETDYNE)

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1-86	3	16 Apr 71
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1-90	6	13 Sep 72
1-91	0	Original
1-92	2	5 Jan 71
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1-94	1	22 Sep 70
1-95	0	Original
1-96	2	5 Jan 71
1-97 thru 1-101	0	Original
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1-132	7	9 Mar 73
1-132A/1-132B	6	13 Sep 72
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1-134 thru 1-135	1	22 Sep 70
1-136	6	13 Sep 72
1-136A thru 1-136B	1	22 Sep 70
1-137	2	5 Jan 71
1-138	0	Original
1-138A thru 1-138B	1	22 Sep 70
1-139 thru 1-141	1	22 Sep 70
1-142	0	Original
1-143/1-144	8	5 Jul 73
1-145/1-146	5	27 Jan 72
1-147 thru 1-148 Deleted	4	13 Aug 71
1-149 thru 1-163	0	Original
1-164	1	22 Sep 70
1-164A	2	5 Jan 71
1-164B	1	22 Sep 70
1-164C	5	27 Jan 72
1-164D	9	15 Mar 75
1-165	1	22 Sep 70
1-166 thru 1-168	0	Original
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1-186	6	13 Sep 72
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1-189 thru 1-190 Deleted	4	13 Aug 71
1-191	4	13 Aug 71
1-192	1	22 Sep 70
1-193	6	13 Sep 72
1-194	9	15 Mar 75
1-195	6	13 Sep 72
1-196	9	15 Mar 75
1-197	6	13 Sep 72
1-198	0	Original
1-199	3	16 Apr 71
1-200 thru 1-205	0	Original
1-206 thru 1-206C	1	22 Sep 70
1-206D	8	5 Jul 73
1-206E thru 1-206F	2	5 Jan 71
1-207	1	22 Sep 70
1-208	7	9 Mar 73
1-209 thru 1-211/1-212	0	Original
2-1 thru 2-4	0	Original
2-5	8	5 Jul 73
2-6	7	9 Mar 73
2-7 thru 2-8A/2-8B	4	13 Aug 71
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2-10 thru 2-11	0	Original
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2-21 thru 2-24B	1	22 Sep 70
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2-41	6	13 Sep 72
2-42 thru 2-43	0	Original
2-44	8	5 Jul 73
2-45	5	27 Jan 72
2-46	1	22 Sep 70
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2-48M	5	27 Jan 72
2-49 thru 2-51	0	Original
2-52	1	22 Sep 70
2-53 thru 2-59	0	Original
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3-134 thru 3-135	5	27 Jan 72
3-136	4	13 Aug 71
3-137	5	27 Jan 72
3-138	9	15 Mar 75
3-139 thru 3-140	5	27 Jan 72
3-141	9	15 Mar 75
3-142 thru 3-143	5	27 Jan 72
3-144 thru 3-144A/3-144B	6	13 Sep 72
3-145	6	13 Sep 72
3-146	4	13 Aug 71
3-147	5	27 Jan 72
3-148	4	13 Aug 71
3-149 thru 3-151	5	27 Jan 72
3-152 thru 3-152B	6	13 Sep 72
3-152C/3-152D	9	15 Mar 75
3-153 thru 3-154A	5	27 Jan 72
3-154B	6	13 Sep 72
3-155	6	13 Sep 72
3-156	5	27 Jan 72
3-157	0	Original
3-158	4	13 Aug 71
3-159 thru 3-160	0	Original
3-161	9	15 Mar 75
3-162 thru 3-164	0	Original
3-165 thru 3-166	1	22 Sep 70
3-166A thru 3-166B	3	16 Apr 71
3-167	1	22 Sep 70
3-168	0	Original
3-169	3	16 Apr 71
3-170	1	22 Sep 70
3-171	0	Original
3-172 thru 3-173	2	5 Jan 71
3-174	9	15 Mar 75
3-175	2	5 Jan 71
3-176	9	15 Mar 75
3-177	0	Original
3-178	1	22 Sep 70
3-179	0	Original
3-180 thru 3-181	8	5 Jul 73
3-182 thru 3-183	9	15 Mar 75
3-184	1	22 Sep 70
3-185 thru 3-187	9	15 Mar 75
3-188	8	5 Jul 73
3-189 thru 3-192	1	22 Sep 70
3-193 thru 3-194	0	Original
3-195	9	15 Mar 75
3-196	1	22 Sep 70
3-197	9	15 Mar 75
3-198	0	Original
3-199	9	15 Mar 75
3-200	0	Original
3-201	8	5 Jul 73
3-202	0	Original
3-202A/3-202B	6	13 Sep 72
3-203	6	13 Sep 72
3-204	0	Original
3-205	9	15 Mar 75
3-206	1	22 Sep 70
3-207	2	5 Jan 71
3-208	0	Original
3-209	9	15 Mar 75
3-210	6	13 Sep 72
3-211	9	15 Mar 75
3-212 thru 3-213	1	22 Sep 70
3-214 thru 3-215	0	Original
3-216 thru 3-222	6	13 Sep 72
3-223	0	Original
3-224	5	27 Jan 72
3-225	0	Original
3-226 thru 3-226A/3-226B	7	9 Mar 73
3-227	7	9 Mar 73
3-228	9	15 Mar 75
3-228A thru 3-228B	1	22 Sep 70
3-229	9	15 Mar 75
3-230	2	5 Jan 71
3-230A thru 3-230B	6	13 Sep 72
3-231	6	13 Sep 72
3-232	2	5 Jan 71
3-232A	6	13 Sep 72
3-232B	4	13 Aug 71
3-233	4	13 Aug 71
3-234 thru 3-238	0	Original
3-239 thru 3-240	5	27 Jan 72
3-241	0	Original
3-242	7	9 Mar 73
3-243 thru 3-244	0	Original
3-245	8	5 Jul 73
3-246 thru 3-249	0	Original
3-250 thru 3-251	9	15 Mar 75
3-252	0	Original
3-253	10	22 Apr 75
3-254 thru 3-258	0	Original
3-259	9	15 Mar 75
3-260	0	Original
3-261	3	16 Apr 71
3-262 thru 3-267	0	Original
3-268 thru 3-269	9	15 Mar 75
3-270 thru 3-271	0	Original
3-272 thru 3-273	5	27 Jan 72
3-274	0	Original
3-275	5	27 Jan 72
3-276	6	13 Sep 72
3-277	9	15 Mar 75
3-278	1	22 Sep 70
3-279	3	16 Apr 71
3-280	6	13 Sep 72
3-281 thru 3-282	0	Original
3-283	9	15 Mar 75
3-284	2	5 Jan 71
3-284A	1	22 Sep 70
3-284B	2	5 Jan 71
3-284C thru 3-284D	9	15 Mar 75
3-285	9	15 Mar 75
3-286 thru 3-293	0	Original
3-294	2	5 Jan 71
3-295	1	22 Sep 70
3-296 thru 3-304	0	Original
3-305	7	9 Mar 73
3-306 thru 3-308A/3-308B	6	13 Sep 72
3-309	6	13 Sep 72
3-310 thru 3-312	3	16 Apr 71
3-312A/3-312B	6	13 Sep 72
3-313	6	13 Sep 72
3-314	11	9 May 75
3-315 thru 3-316	3	16 Apr 71
3-317 thru 3-318B	6	13 Sep 72
3-319	6	13 Sep 72
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3-331	5	27 Jan 72
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3-339 thru 3-340	8	5 Jul 73
3-341 thru 3-347	0	Original
3-348 thru 3-348A/3-348B	5	27 Jan 72
3-349	6	13 Sep 72
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INTRODUCTION

SCOPE. This manual contains operating requirements and recommended procedures to support these requirements, for the J-2 Rocket Engine, Part Number 103826, Serial Numbers J-2036-1 through J-2152, designed and manufactured by Rocketdyne Division, Rockwell International, 6633 Canoga Avenue, Canoga Park, California 91304.

1. OUTLINE OF ENGINE OPERATING INSTRUCTIONS INFORMATION.

Operating and General Requirements.

Section I, Operating Requirements, and section II, General Requirements, provide all the specific and general requirements for the activities to be performed, acceptability criteria for these activities, and limits, special constraints, safety precautions, and sequences required to satisfactorily accomplish the activities.

Operating Procedures.

Section III outlines the procedures recommended by the Engine Contractor to satisfy the requirements of sections I and II most effectively. Where applicable, maintenance and repair type manuals are referenced to avoid duplication of existing field procedures for maintenance and repair, routine handling, and engine buildup.

2. ENGINE OPERATING INSTRUCTIONS (EOI) CONTROL AND REVISION SYSTEM.

Index of ECP Changes.

The 11 July 1969 issue of this manual incorporated engine operating requirements for the ECPs and corresponding engine MD numbers listed in figure 1 that were contractually approved as of 11 July 1969. These ECPs form the approval baseline for this manual. The index of ECP changes, figure 2, reflects the ECP changes that were issued after the initial release of this manual. The index of ECP changes includes the approved ECP number, the related engine MD number (if applicable), and the date the change made by the ECP was incorporated in the manual or the notation N/A to signify that the ECP does not change the data in the manual.

Engine Baseline Configuration.

Figure 3 represents the engine baseline configuration for requirements and procedures included in this manual. The manual is coded for engines incorporating or not incorporating, as applicable, MD configurations that are different from the baseline model.

Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.
J2-12	1	J2-99	14	J2-195	88,111	J2-286	3
J2-13	1	J2-100	10	J2-195R1	--	J2-287	9
J2-14	3	J2-101	27	J2-195R2	--	J2-288	3
J2-15	1	J2-102	38	J2-195R3	--	J2-289	9
J2-17	5	J2-103	8	J2-195R4	--	J2-290	9
J2-18	6	J2-105	26	J2-196	9	J2-293	105
J2-19	5	J2-106	9	J2-198	3	J2-296	35
J2-20	64	J2-107	42	J2-199	97	J2-296R1	--
J2-20R1	--	J2-108	37	J2-200	23	J2-298	50,129
J2-24	8	J2-109	3	J2-202	37	J2-298R1	--
J2-26	9	J2-110	36	J2-204	56	J2-300	107
J2-31	9	J2-112	13	J2-207	--	J2-303	56
J2-33	77	J2-113	34	J2-218	56	J2-306	9
J2-36	1	J2-115	32	J2-226	3	J2-307	9
J2-39	8	J2-117	9	J2-227	99	J2-308	56
J2-41	2	J2-121	9	J2-229	108	J2-310	137
J2-44	61	J2-122	8	J2-229R1	--	J2-310R1	--
J2-44R1	--	J2-123	43	J2-232	9	J2-310R2	--
J2-45	3	J2-124	60	J2-235	58	J2-312	9
J2-46	5	J2-125	56	J2-236	72	J2-313	119
J2-47	10	J2-126	3	J2-240	3	J2-315	70
J2-48	28	J2-127	26	J2-241	86	J2-316	19
J2-51	16	J2-128	53	J2-243	19	J2-317	9
J2-52	1	J2-129	40	J2-246	3	J2-318	153
J2-55	7	J2-130	3	J2-247	76	J2-318R1	--
J2-57	11	J2-139	23	J2-248	106	J2-319	123
J2-62	9	J2-140	41	J2-249	84	J2-319R1	--
J2-63	77	J2-141	9	J2-250	87	J2-319R2	--
J2-64	9	J2-146	9	J2-251	78	J2-320	100
J2-66	26	J2-147	9	J2-252	56,94	J2-320R1	--
J2-67	14	J2-151	11	J2-254	88,91	J2-321	118
J2-69	77	J2-152	79	J2-254R1	--	J2-322	116
J2-74	70	J2-154	23	J2-254R2	--	J2-329	133,338
J2-75	18	J2-157	44	J2-254R3	--	J2-329R1	--
J2-76	56	J2-158	51	J2-254R4	--	J2-329R2	--
J2-77	17	J2-159	23	J2-255	88,187	J2-330	88
J2-78	20	J2-160	47	J2-255ER1	--	J2-331	117
J2-79	55	J2-161	68	J2-255ER2	--	J2-331R1	--
J2-80	11	J2-161R1	--	J2-255ER3	--	J2-332	9
J2-81	9	J2-161R2	--	J2-255ER4	--	J2-333	141
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J2-92	8	J2-185	80	J2-271R3	--	J2-350	15
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J2-96	72	J2-191	64	J2-284	101	J2-351R1	--
J2-97	25	J2-191R1	--	J2-285	58	J2-352	56

Figure 1. ECP Approval Baseline (Sheet 1 of 3)

Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.	Approved ECP No.	Engine MD No.
J2-358	--	J2-399R1	--	J2-435R1	--	J2-477	239,310
J2-359	140	J2-399R2	--	J2-437	192,246	J2-477R1	--
J2-359R1	--	J2-399R3	--	J2-437R1	--	J2-477R2	--
J2-360	139	J2-399R4	--	J2-437R2	--	J2-479	206,232
J2-360R1	--	J2-401	152	J2-438	185	J2-479R1	--
J2-360R2	--	J2-403	157	J2-440	201	J2-479R2	--
J2-361	30,127	J2-403R1	--	J2-445	172	J2-479R3	--
J2-362	131	J2-403R2	--	J2-449	183	J2-481	217
J2-363	138	J2-404	88	J2-449R1	--	J2-482	222
J2-363R1	--	J2-405	237	J2-451	172,206	J2-482R1	--
J2-364	132	J2-405R1	--	J2-452	184	J2-483	224,225,292
J2-365	142	J2-405R2	--	J2-455	188,198	J2-483R1	--
J2-366	128	J2-407	88	J2-455R1	--	J2-483R2	--
J2-367	70	J2-408	155,227	J2-455R2	--	J2-483R3	--
J2-368	130	J2-408R1	--	J2-455R3	--	J2-483R4	--
J2-368R1	--	J2-409	166	J2-458	191	J2-485	--
J2-369	151	J2-409R1	--	J2-458R1	--	J2-488	208
J2-369R1	--	J2-409R2	--	J2-459	205	J2-488R1	--
J2-369R2	--	J2-410	160	J2-459R1	--	J2-489	185
J2-369R3	--	J2-410R1	--	J2-459R2	--	J2-489R1	--
J2-369R4	--	J2-413	161	J2-461	204	J2-489R2	--
J2-370	150,280,281	J2-413R1	--	J2-461R1	--	J2-492	223
J2-370R1	--	J2-414	174	J2-461R2	--	J2-492R1	--
J2-370R2	--	J2-414R1	--	J2-463	189	J2-492R2	--
J2-371	70	J2-414R2	--	J2-465	190,334	J2-492R3	--
J2-372	134	J2-415	170,200,339	J2-465R1	--	J2-493	185
J2-376	135	J2-415R1	--	J2-466	239,310	J2-494	210
J2-380	136	J2-415R2	--	J2-466R1	--	J2-495	207
J2-382	130	J2-415R3	--	J2-466R2	--	J2-496	203
J2-383	158	J2-416	164,165	J2-467	212	J2-497	213
J2-383R1	--	J2-416R1	--	J2-468	172	J2-497R1	--
J2-387	149,154	J2-417	173	J2-468R1	--	J2-499	--
J2-387R1	--	J2-419	168,169	J2-469	195	J2-499R1	--
J2-387R2	--	J2-421	172	J2-469R1	--	J2-499R2	--
J2-387R3	--	J2-421R1	--	J2-470	211,319	J2-500	209
J2-387R4	--	J2-422	171	J2-470R1	--	J2-501	--
J2-388	166	J2-423	--	J2-471	212,228	J2-501R1	--
J2-389	144	J2-424	--	J2-471R1	--	J2-501R2	--
J2-389R1	--	J2-426	185	J2-471R2	--	J2-505	214
J2-389R2	--	J2-428	194	J2-474	215,231,245	J2-507	226
J2-390	143	J2-429	185	J2-474R1	--	J2-507R1	--
J2-390R1	--	J2-430	172	J2-474R2	--	J2-510	218
J2-391	88	J2-430R1	--	J2-474R3	--	J2-511	219
J2-391R1	--	J2-430R2	--	J2-474R4	--	J2-511R1	--
J2-394	148	J2-430R3	--	J2-474R5	--	J2-513	221
J2-394R1	--	J2-431	177	J2-475	--	J2-513R1	--
J2-395	146	J2-431R1	--	J2-475R1	--	J2-514	--
J2-395R1	--	J2-431R2	--	J2-475R2	--	J2-522	--
J2-397	156	J2-432	176	J2-476	196	J2-522R1	--
J2-398	182	J2-433	178	J2-476R1	--		
J2-398R1	--	J2-434	180,181	J2-476R2	--		
J2-399	163,167,202	J2-435	179	J2-476R3	--		

Figure 1. ECP Approval Baseline (Sheet 2 of 3)

Approved ECP No.	Engine MD No.
J2-522R2	--
J2-523	233
J2-524	229
J2-525	234
J2-525R1	--
J2-527	238, 248, 250, 290, 341
J2-527R1	--
J2-527R2	--
J2-527R3	--
J2-528	--
J2-529	230
J2-531	243
J2-532	270
J2-532R1	--
J2-538	244
J2-538R1	--
J2-540	240
J2-541	--
J2-541R1	--
J2-542	242
J2-544	236
J2-545	235
J2-546	243
J2-546R1	--
J2-547	241
J2-547R1	--
J2-547R2	--
J2-548	237
J2-549	247
J2-550	262
J2-551	276, 277
J2-551R1	--
J2-552	251, 252
J2-552R1	--
J2-552R2	--
J2-553	254, 347
J2-553R1	--
J2-556	--
J2-557	249
J2-558	258, 261, 321
J2-558R1	--
J2-559	--
J2-560	--
J2-561	273
J2-566	243
J2-566R1	--
J2-567	275
J2-567R1	--
J2-568	271
J2-570	294
J2-571	239
J2-571R1	--
J2-575	256, 267, 278
J2-575R1	--
J2-575R2	--
J2-575R3	--
J2-575R4	--
J2-575R5	--
J2-576	--
J2-577	--
J2-577R1	--
J2-577R2	--
J2-577R3	--
J2-580	--
J2-581	257, 318
J2-581R1	--
J2-581R2	--
J2-581R3	--
J2-582	259
J2-587	291
J2-588	263, 274, 355
J2-588R1	--
J2-588R2	--
J2-588R3	--
J2-589	--
J2-590	260
J2-590R1	--
J2-590R2	--
J2-590R3	--
J2-590R5	--
J2-592	272
J2-594	268, 269, 279, 282, 296 313, 314, 315
J2-594R1	--
J2-594R2	--
J2-594R3	--
J2-598	266
J2-599	265
J2-599R1	--
J2-599R2	--
J2-600	239
J2-601	283
J2-601R1	--
J2-602	284, 285
J2-602R1	--
J2-603	286
J2-603R1	--
J2-603R2	--
J2-604	--
J2-605	287
J2-606	324
J2-606R1	--
J2-607	288, 289, 297, 298, 299, 305, 306, 307, 308, 309, 352
J2-607R1	--
J2-607R2	--
J2-608	300
J2-612	293
J2-612R1	--
J2-613	--
J2-614	--
J2-616	303, 304
J2-618	270
J2-620	295, 301, 302, 322, 323
J2-620R1	--
J2-620R2	--
J2-620R3	--
J2-621	311, 312
J2-624	316, 317 320, 342, 351
J2-624R1	--
J2-624R2	--
J2-627	--
J2-631	325
J2-632	--
J2-633	340, 349, 350
J2-634	--
J2-636	333
J2-636R1	--
J2-637	335
J2-640	336
J2-640R1	--
J2-641	348
J2-642	--
J2-643	328, 329, 330, 331, 332, 344, 345
J2-643R1	--
J2-643R2	--
J2-645	--
J2-646	337
J2-647	343
J2-647R1	--
J2-649	--
J2-650	--
J2-651	--
J2-652	--
J2-654	346
J2-656	354
J2-657	353
J2-657R1	--
J2-657R2	--
J2-659	358
J2-662	360
J2-666	359
J2-666R1	--
J2-666R3	--
J2-668	361

Figure 1. ECP Approval Baseline (Sheet 3 of 3)

Approved ECP No.	MD No.	Incorporated in Manual Dated
J2-653R2	--	2 February 1970
J2-671	--	N/A
J2-675	362	N/A
J2-689	365, 366	22 September 1970
J2-689R1	--	N/A
J2-689R2	371	22 September 1970
J2-689R3	--	N/A
J2-694	363	N/A
J2-694R2	373, 374	N/A
J2-694	363	N/A
J2-694R2	373, 374	N/A
J2-695	364	N/A
J2-697	367	N/A
J2-700	370	N/A
J2-704	372	N/A
J2-708R1	380, 381	13 September 1972
J2-711	376	27 January 1972
J2-714	377, 378, 379	N/A
J2-717	383, 384	13 September 1972

Figure 2. Index of ECP Changes

3 x 5   11 x 13   20 x 23 x 25   28 x 30 x 32 x 34   38 x 40   51 x 53   61 x 64 x 68   70 x 72 x 76

80 x 82 x 84 x 86   88 x 91   92 x 94 x 97 x 99 x 101 x 106   109 x 111 x 116   125 x 127   132 x 134

135 x 137   144 x 146 x 148   149 x 151   153 x 155 x 157   158 x 161 x 163   164 x 168   170 x 173

174 x 176 x 178   179 x 181 x 187   188 x 198 x 200 x 202 x 209 x 215 x 218   219 x 226 x 230

231 x 233 x 241 x 244 x 249 x 266 x 268 x 277 x 279 x 284   285 x 289 x 293 x 298 x 303 x 314 x 316

317 x 339 x 341   342

Figure 3. Engine Baseline MD Configuration

3. ABBREVIATIONS.

The following abbreviations appear throughout this manual:

ASI	Augmented spark igniter
ECA	Electrical control assembly
EMR	Engine mixture ratio
FI	Flight instrumentation
GG	Gas generator
HB	Huntington Beach (McDonnell-Douglas Corporation)
Hz	Hertz (frequency in cycles per second)
KSC	Kennedy Space Center
MFV	Main fuel valve
mm Hg	Millimeters of mercury (vacuum)
MOV	Main oxidizer valve
MRCV	Mixture ratio control valve
MTF	Mississippi Test Facility (NASA)
NASA	National Aeronautics and Space Administration
NPSH	Net positive suction head
OTBV	Oxidizer turbine bypass valve
PU	Propellant utilization
SAC/MDAC	Sacramento Test Site (McDonnell-Douglas Corporation)
SB	Seal Beach (Space Division)
SIC	Spark igniter cable
STDV	Start tank discharge valve
VAB	Vertical Assembly Building (KSC)
VSC	Vibration safety cutoff

4. DEFINITIONS.

Stage Contractor	McDonnell-Douglas Corporation (SIVB stage) or Space Division, Rockwell International (SII stage)
Engine Contractor	Rocketdyne Division, Rockwell International, and its designated representatives, such as field engineering personnel
Customer	NASA and its designated representatives
Uninstalled engines	Engines installed on a handler or stored vertically
Installed engines	Engines installed in the SIVB stage or in the SII stage
Damage is not allowable.	Defined in paragraph 2.4.4
Engine service life	Defined in paragraph 2.5.7
Engine start	Defined in paragraph 2.5.7
Component cycle	Defined in paragraph 2.5.8
Gimbal cycle	Defined in paragraph 2.5.9
Leakage is not allowable.	Defined in paragraph 2.5.10
Nonrestart-mission engines	SII-stage and SIVB-stage engines in a configuration that enables a single firing operation in flight.

Restart-mission engines	SIVB-stage engines in a configuration that enables multiple firing operations in flight.
Activities	Required operations and, if applicable, the event and/or site scheduled for the performance of the operations.
Requirements	Specific tasks to be performed during an activity and the conditions under which the tasks must be performed.
Limits	The acceptable results of tasks performed in accordance with the corresponding requirements.
Constraints	Special conditions, qualifications, results, or limitations that are complementary to the activity, requirements, and limits.
Remarks	Nonconstraining information that highlights the activities, requirements, and limits.
Engine Contractor minimum requirement (ECMR)	Activity required to verify that the engine meets minimum requirements defined by the Engine Contractor. Activities listed without ECMR code may be performed but are not required by the Engine Contractor.

5. CONFIGURATION IDENTIFICATION.

Equipment Configuration.

The MD identification symbol and the equipment model designation indicate the configuration of the equipment and distinguish it from models incorporating different changes and from basic models. A basic, unchanged configuration of the equipment has no MD identification symbol. MD identification symbols are added as changes affecting configuration are incorporated into the equipment. The MD identification symbol is stamped on the MD plate, which is mounted near the engine nameplate.

MD Identification Symbols.

The MD identification symbol is a composite number that represents all the changes affecting configuration (MD changes) incorporated or not incorporated into the equipment. The symbol represents a consecutively numbered series of MD changes. Any MD change, or series of MD changes, not incorporated is represented by an "X." Multi-digit numbers are underlined. Two figures together represent the limits of a series of incorporated MD changes. Figure 4 illustrates how MD changes incorporated in the engine are represented by the MD identification symbol.

Manual Reference.

A reference that appears in the manual may refer to a series of MD changes or to an individual MD change; for example, "MD9" refers to MD1 through MD9, but "MD9 change" refers to the individual MD change 9. This latter type of reference, illustrated in figure 4, identifies separate sets of information required by differences in configuration. When an MD reference appears in the manual, examine the MD identification symbol on the equipment to determine which set of information is applicable.

6. ADDITIONAL DATA AND INFORMATION.

The following documents provide additional information on the J-2 rocket engine (figure 5) and J-2 ground support equipment and tooling. The instructions in the manuals are used more effectively when each manual is current and complete. (See figure 6.)

R-3825-1, J-2 Rocket Engine Data Manual. This manual provides descriptive, operational, and performance data.

R-3825-3, J-2 Rocket Engine Maintenance and Repair Manual (Volume I). This manual provides engine handling, component removal and installation, post-maintenance testing, and in-place tube welding requirements and procedures.

R-3825-3, J-2 Rocket Engine Maintenance and Repair Manual (Volume II). This manual contains component repair and testing, and preinstallation testing procedures for individual engine components.

R-3825-4, J-2 Rocket Engine Illustrated Parts Breakdown Manual. This manual lists and illustrates the parts required for maintenance-level support of the J-2 rocket engine, including closures for the assembled J-2 rocket engine and its individual components and parts.

R-3825-5, J-2 Rocket Engine Ground Support Equipment Maintenance and Repair Manual (Volumes I and II). This manual provides maintenance and repair data for engine ground support equipment.

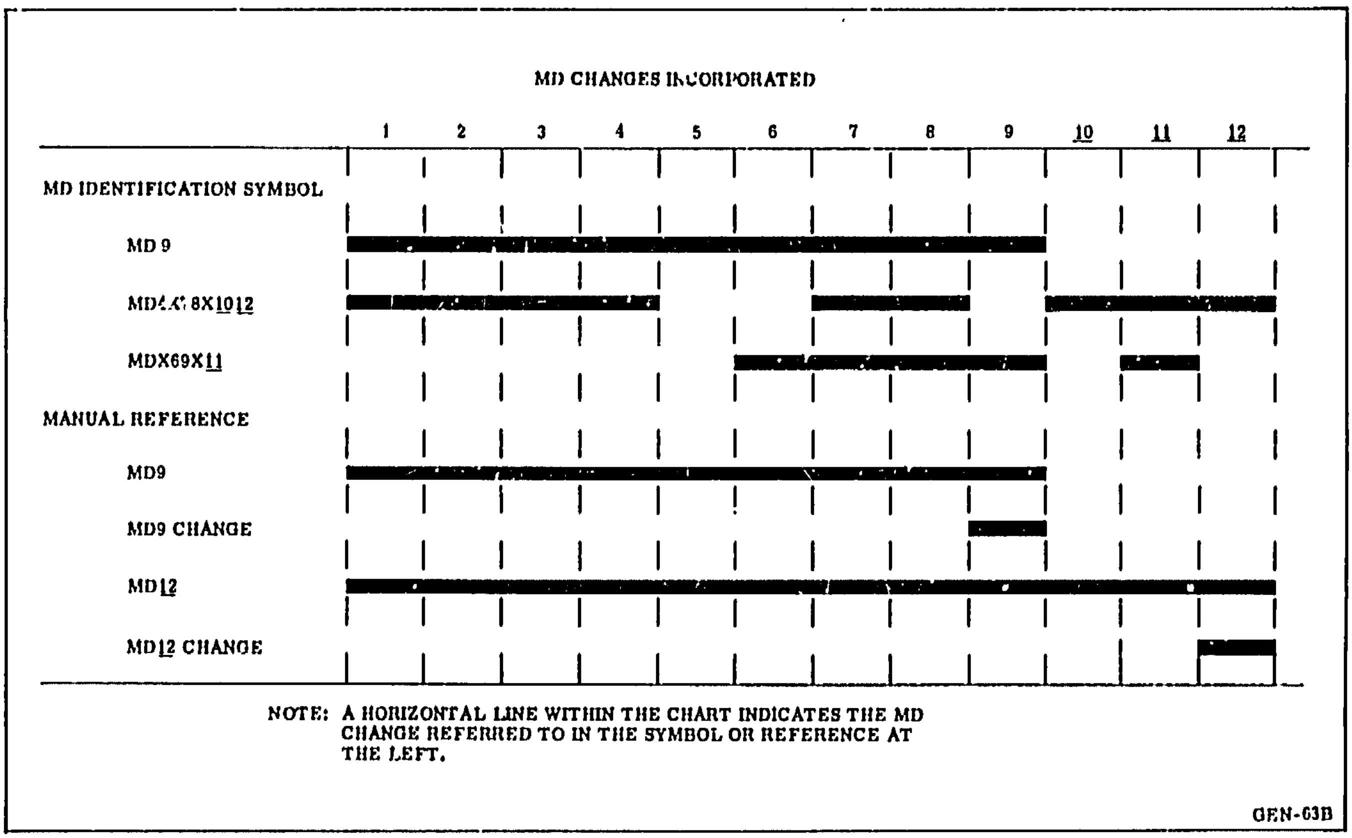


Figure 4. MD System

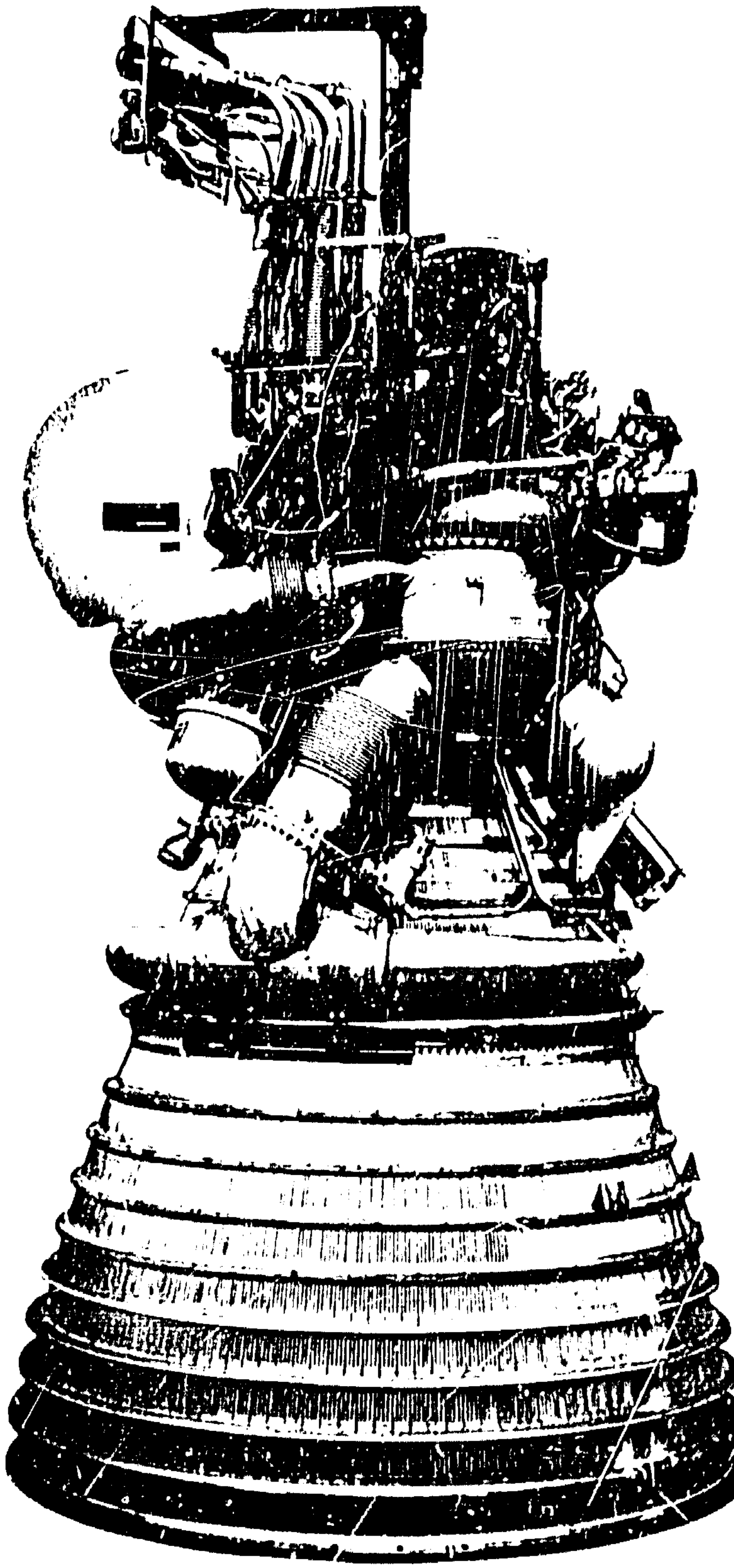
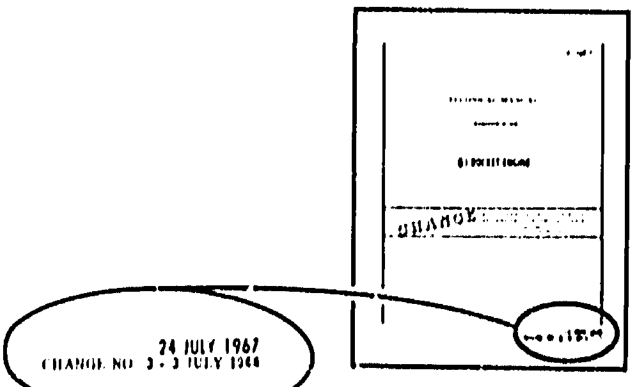


Figure 5. J-2 Rocket Engine

USE YOUR MANUAL ONLY IF CURRENT AND COMPLETE

Manuals that are not current and complete are not authoritative documents and are not to be used. The following outlines the method for determining whether your manual is current and complete.

A. DETERMINING CURRENCY. To be sure that yours is the latest issue of the manual, refer to Configuration Identification & Status Report , which is revised monthly and lists the technical manual numbers, titles, unincorporated supplements, and latest change or revision dates. Your manual must have a title page with the same or later date than the date shown in the Configuration Identification & Status Report. Your manual must also include the unincorporated supplements listed in the Configuration Identification & Status Report, or if your manual is later than shown in the report, the unincorporated supplements listed in the Manual Data Supplement Record in your manual. If your title page incorporates two dates as illustrated below, compare the change (lower) date. If your manual is not current, obtain a current copy through your technical manual supply system.

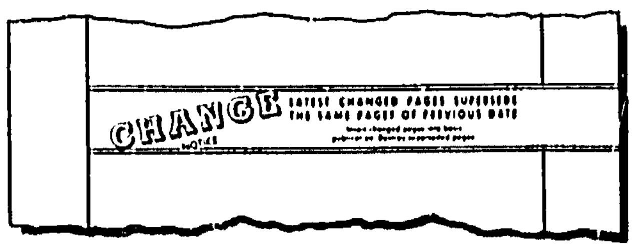


B. DETERMINING COMPLETENESS. To be sure that your manual is complete, make a page-by-page comparison of its pages to those listed in the List of Effective Pages. The List of Effective Pages, which shows the change status since the basic issue or last revision, is found on the alphabetically lettered page(s) immediately following the title page. All pages, except supplements, are listed with their issue dates. Manual pages that are dated must have the same date as that appearing in the List of Effective Pages for that page. Unchanged pages are listed as "original" and are not dated.

HOW TO KEEP YOUR MANUAL UP-TO-DATE

As design changes are made to the rocket engine and ground support equipment and better methods of maintenance are discovered, your manual is periodically changed, revised, or supplemented. The following steps will help you keep your manual up-to-date:

A. CHANGES. Updating by adding to or partially replacing existing pages is defined as a change. Changes can be identified by the change notice on the new title page.



To collate a change, refer to the Filing Instructions sheet issued with the manual and proceed as follows:

1. Remove the pages listed in the "Remove" column of the Filing Instructions sheet from the manual and destroy them. Do not concern yourself with the data on the opposite side of the deleted page since, if this data is not deleted, it is replaced in the change package.

2. Insert all pages listed in the "Insert" column of the Filing Instructions sheet in sequence. Pages with a suffix letter are inserted in alphabetical order following the page with the same basic number; for example, pages 3-14A, 3-14B, etc, follow page 3-14.

GEN-NASA-1A

Figure 6. How to Maintain Your Manual (Sheet 1 of 2)

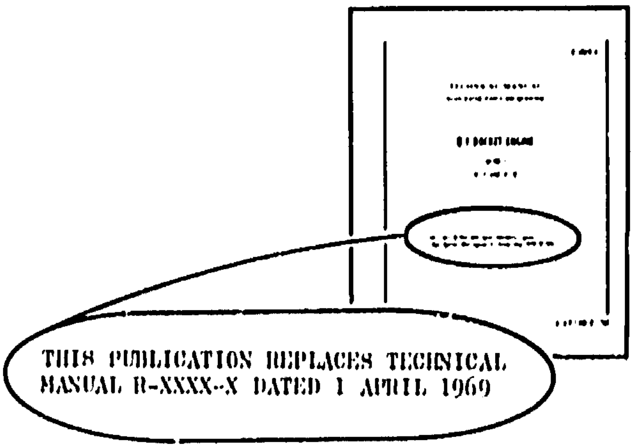
3. If you are unsure of the status of any page or pages, refer to the List of Effective Pages and make sure your manual contains pages (with the corresponding change dates) listed in the List of Effective Pages.

4. Remove manual supplements that have been incorporated.

NOTE

Incorporated supplements can be determined by reviewing the newly issued Manual Data Supplement Record.

B. REVISIONS. Updating by replacing all the existing pages of a manual is defined as a revision. Revisions can be identified by the replacement notice on the new title page.



To collate a revision, proceed as follows:

1. Remove and destroy all existing pages of your manual except Manual Data Supplements that have not been incorporated.

NOTE

Unincorporated supplements can be identified by reviewing the Manual Data Supplement Record supplied in the revision.

2. Insert the new pages in your cover.

C. SUPPLEMENTS. Updating that authorizes the addition to, or alteration of, the existing data in your manual is defined as a Manual Data Supplement. Information on how to insert supplements is found in the supplements.

HOW TO KEEP ABREAST OF THE LATEST CHANGES TO TECHNICAL DATA

Changes and/or additions to technical data are identified by a vertical bar (change bar) in the margin of the page adjacent to the changed data. A direct comparison between the new (identified by the change bar) and the old data will help you in identifying specific changes made.

GEN-NASA-2

Figure 6. How to Maintain Your Manual (Sheet 2 of 2)

SECTION I

OPERATING REQUIREMENTS

SCOPE. This section outlines the scheduled and nonscheduled authorized engine activities and the requirements, limits, and constraints necessary to satisfactorily comply with these activities.

Scheduled Authorized Field Activities, figure 1-1, lists from left to right the major engine events with respect to engine status (an uninstalled engine or an engine installed in a stage). All activities for each event should be accomplished before starting the next event. Activities listed for each event may be performed in any order unless otherwise specified in the referenced activity paragraph contained in the requirements, limits, and constraints tabular presentation.

Nonscheduled Authorized Field Activities, figure 1-2, lists the activities that must be performed during nonscheduled events. The events listed across the top of this figure are grouped to reflect the location and conditions that prevailed at the time the nonscheduled activity became necessary. The listed order of these events is not sequence oriented; therefore, the activities may be performed in any order unless otherwise specified in the referenced activity paragraph contained in the requirements, limits, and constraints tabular presentation. During stage acceptance test and launch abort activities, it is assumed that abort was not caused by engine-associated problems.

Requirements, limits, and constraints are presented in tabular form immediately following figure 1-2. These activities must be accomplished during that phase of scheduled or nonscheduled engine flow specified in figures 1-1 and 1-2. During compliance with these activities, the following general requirements shall apply.

a. The safety precautions specified in section II must be complied with.

b. When the activity requires the application of a specific purge, the purge pressures and flowrates specified in section II must be applied, unless otherwise specified.

c. When an activity requires pressurizing or purging a system or component, the fluid requirements specified in section II must be complied with.

Activity Number	Event / Activity	HB AND SB: UNINSTALLED ENGINES: Receiving Inspection	Storage Preparation	Storage	Removal From Storage	Checkout	Installation in Stage	HB AND SB: STAGE: Post-Manufacturing	Storage Preparation	Storage	Removal From Storage	Shipment	STAGE/VEHICLE (KSC): Receiving Inspection	Storage Preparation	Storage	Removal From Storage	Inspection and Checkout at VAB	Flight Readiness Test	Countdown Demonstration Test	Countdown Demonstration Test—Securing	Launch Preparation
		A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U	V
	INSPECTIONS																				
1	Engine visual	1.1.1			1.1.1 (c)			1.1.2			1.1.9 (c)		1.1.4			1.1.9 (c)	1.1.9		1.1.10 (a)	1.1.11 (a)	1.1.12 (a)
2	Engine Log Book orifice verification	1.1.13										1.1.13					1.1.13 (a)				
3	Engine Log Book audit	1.1.14										1.1.14									1.1.14 (a)
4	Engine gimbaling clearance check																1.1.15 (a)				
5	Humidity	1.1.16 (a)	1.1.18 (a)	1.1.18 (a)	1.1.16 (c)	1.1.16 (a)	1.1.16 (a)	1.1.16 (a)	1.1.17 (a)	1.1.17 (a)	1.1.16 (c)	1.1.16 (a)	1.1.16 (a)	1.1.17 (a)	1.1.17 (a)	1.1.16 (c)	1.1.16 (a)				
5A	Stress corrosion inspection		1.1.19		1.1.19				1.1.19					1.1.19		1.1.19	1.1.19	1.1.19		1.1.19	
	ELECTRICAL TESTS																				
6	Flight instrumentation system test					1.2.1		1.2.4									1.2.4 (a)				1.2.4 (a)
7	Propellant utilization valve test (engines not incorporating MD366 or MD371 change)					1.2.2											1.2.7 (a)		1.2.8 (a)		1.2.8 (a)
8	Mixture ratio control valve test (engines incorporating MD366 or MD371 change)					1.2.2A													1.2.8A (a)		1.2.8A (a)
9	Ignition-phase control valve, mainstage control valve, start tank discharge valve control valve, helium control valve, helium tank emergency vent valve, start tank emergency vent valve, and mixture ratio control valve resistance test				1.2.9 (b)						1.2.9 (b)					1.2.9 (b)	1.2.9 (b)				
10	Engine electrical system resistance-to-ground test				1.2.10 (b)						1.2.10 (b)					1.2.10 (b)	1.2.10 (a)				
11	Engine electrical safety circuit test				1.2.3 (b)	1.2.3		1.2.11			1.2.11 (b)					1.2.11 (b)	1.2.11 (a)				
12	Spark igniter test				1.2.12 (b)	1.2.12					1.2.12 (b)					1.2.12 (b)	1.2.12 (a)				
	LEAK AND FUNCTION TESTS																				
13	Electrical control assembly package and primary and auxiliary flight instrumentation package pressure measurement		1.3.1 (a)		1.3.1 (c)				1.3.1 (a)		1.3.1 (c)			1.3.1 (a)		1.3.1 (c)	1.3.1 (a)				

(a) Engine Contractor minimum requirement.
(b) Must be performed within 6 months after removal from storage controlled environment.
(c) Must be performed within 14 days after removal from storage controlled environment.

Figure 1-1. Scheduled Authorized Field Activities (Sheet 1 of 6)

Activity Number	Activity \ Event	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U	V
		HB AND SB											STAGE/VEHICLE (KSC)								
		UNINSTALLED ENGINES						STAGE													
		Receiving Inspection	Storage Preparation	Storage	Removal From Storage	Checkout	Installation in Stage	Post-Manufacturing	Storage Preparation	Storage	Removal From Storage	Shipment	Receiving Inspection	Storage Preparation	Storage	Removal From Storage	Inspection and Checkout at VAB	Flight Readiness Test	Countdown Demonstration Test	Countdown Demonstration Test--Securing	Launch Preparation
	LEAK AND FUNCTION TESTS (cont)																				
14	Spark igniter cable pressure measurement		(a) 1,3,2		(c) 1,3,2				(a) 1,3,2		(c) 1,3,2			(a) 1,3,2		(c) 1,3,2	(a) 1,3,2				
15	Start system test					1,3,3		1,3,4									(a) 1,3,5				
16	Start tank emergency vent valve test					1,3,6											1,3,6		(a) 1,3,6		
17	Start tank mass-loss test				(b) 1,3,7	1,3,7											1,3,7			(a) 1,3,7	
18	Start tank pressure-decay test										(b) 1,3,8					(b) 1,3,8	1,3,8			(a) 1,3,8	
19	Start tank discharge valve piston and piston lip seal leak test (engines not incorporating MD275 change)										(b) 1,3,9					(b) 1,3,10	(a) 1,3,10				
20	Start tank discharge valve piston lip seal leak test on engines with STDV 304386 (MD275 change)																1,3,12				
21	Start tank discharge valve swing gate leak test																(a) 1,3,13				
22	Oxidizer turbopump torque test				(b) 1,3,14	1,3,14					(b) 1,3,14					(b) 1,3,14	(a) 1,3,14				
23	Fuel turbopump torque test				(b) 1,3,15	1,3,15					(b) 1,3,15					(b) 1,3,15	(a) 1,3,15				
24	Oxidizer feed system test				(b) 1,3,16	1,3,16		1,3,17			(b) 1,3,18					(b) 1,3,19	(a) 1,3,19				
25	Oxidizer turbopump primary seal drain line burst diaphragm leak test																			(a) 1,3,20	
26	Fuel feed system test				(b) 1,3,21	1,3,21		1,3,22			(b) 1,3,23					(b) 1,3,24	(a) 1,3,24				
27	Fuel turbopump secondary seal leak test				(b) 1,3,25	1,3,25					(b) 1,3,26					(b) 1,3,26	(a) 1,3,26				
28	Purge system test					1,3,27											(a) 1,3,28				
29	Purge manifold system customer-connect leak test							1,3,29													
30	Fuel turbopump primary seal drain customer-connect leak test							1,3,30													

(a) Engine Contractor minimum requirement.
(b) Must be performed within 6 months after removal from storage controlled environment.
(c) Must be performed within 14 days after removal from storage controlled environment.

Figure 1-1. Scheduled Authorized Field Activities (Sheet 2 of 6)

Activity Number	Event / Activity	HB AND SB: UNINSTALLED ENGINES: Receiving Inspection	Storage Preparation	Storage	Removal From Storage	Checkout	Installation in Stage	HB AND SB: STAGE: Post-Manufacturing	Storage Preparation	Storage	Removal From Storage	Shipment	STAGE/VEHICLE (KSC): Receiving Inspection	Storage Preparation	Storage	Removal From Storage	Inspection and Checkout at VAB	Flight Readiness Test	Countdown Demonstration Test	Countdown Demonstration Test--Securing	Launch Preparation
		A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U	V
	LEAK AND FUNCTION TESTS (cont)																				
31	Oxidizer turbopump intermediate seal purge check valve reverse-leak test					1,3,31															
32	Fuel turbine seal purge check valve reverse-leak test					1,3,32											1,3,32				
33	Oxidizer turbine seal purge check valve reverse-leak test					1,3,33											1,3,33				
34	Oxidizer turbopump primary seal drain line leak test					1,3,34		1,3,34									1,3,34				
35	Fuel turbopump primary seal drain check valve reverse-leak test					1,3,35											1,3,35				
36	Fuel turbopump primary seal purge check valve reverse-leak test					1,3,36											1,3,36				
37	Fuel turbopump primary seal drain check valve flow test					1,3,37											1,3,37				
38	Gas generator oxidizer purge check valve reverse-leak test				(b) 1,3,38	1,3,38					(b) 1,3,38					(b) 1,3,38	(a) 1,3,38				
38A	Redundant purge check valve reverse-leak test				(b) 1,3,38A	1,3,38A					(b) 1,3,38A					(b) 1,3,38A	(a) 1,3,38A				
39	Main oxidizer valve sequence control valve lip seal leak test																(a) 1,3,39				
40	Gas generator equalization line leak test					1,3,40															
41	Pneumatic control system test					1,3,41		1,3,42									(a) 1,3,44				
42	Helium supply system leak test					1,3,45											(a) 1,3,45				
43	Helium tank emergency vent control valve test																		(a) 1,3,46		
44	Helium supply system mass-loss test				(b) 1,3,47	1,3,47															
45	Helium supply system pressure-decay test										(b) 1,3,48					(b) 1,3,48	(a) 1,3,48				

(a) Engine Contractor minimum requirement.
(b) Must be performed within 6 months after removal from storage controlled environment.

Figure 1-1. Scheduled Authorized Field Activities (Sheet 3 of 6)

Activity Number	Event / Activity	HB AND SB											STAGE/VEHICLE (KSC)								
		UNINSTALLED ENGINES						STAGE													
		Receiving Inspection	Storage Preparation	Storage	Removal From Storage	Checkout	Installation in Stage	Post-Manufacturing	Storage Preparation	Storage	Removal From Storage	Shipment	Receiving Inspection	Storage Preparation	Storage	Removal From Storage	Inspection and Checkout at VAB	Flight Readiness Test	Countdown Demonstration Test	Countdown Demonstration Test—Securing	Launch Preparation
		A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U	V
	LEAK AND FUNCTION TESTS (cont)																				
46	Helium supply system pressure-decay test (SIVB stage only)																		1.3.48A (a)		1.3.48A (a)
46A	Helium supply system pressure-decay test (SII stage only)																		1.3.48B (a)		1.3.48B (a)
47	Gas generator and exhaust system test					1.3.49											1.3.49 (a)				
48	Thrust chamber test					1.3.50		1.3.51									1.3.52 (a)				
49	Oxidizer tank pressurization system leak test					1.3.53		1.3.54									1.3.55				
50	Start tank vent-and-relief valve drain leak test					1.3.56		1.3.57									1.3.58 (a)				
51	Mainstage OK pressure switch test				1.3.59 (b)	1.3.59					1.3.60 (b)					1.3.60 (b)	1.3.60 (a)				
52	Mainstage OK pressure switch pressure-decay test										1.3.61 (b)					1.3.61 (b)	1.3.61 (a)				
53	Engine sequence test				1.3.62 (b)	1.3.62		1.3.63			1.3.63 (b)					1.3.63 (b)	1.3.63 (a)	1.3.64	1.3.64 (a)		1.3.64 (a)
54	Engine pneumatic system helium usage test										1.3.65 (b)					1.3.65 (b)	1.3.65 (a)				
55	Oxidizer and fuel inlet ducts torsional bellows leak-test																1.3.66 (a)				
	STORAGE AND SHIPMENT PREPARATION																				
56	Engine storage		1.4.1 (a)						1.4.2 (a)					1.4.2 (a)							
57	Engine shipment											1.4.4 (a)									
	SERVICING																				
58	Propellant loading preparation																		1.5.2		1.5.2
59	Thrust chamber conditioning																		1.5.3		1.5.3
60	Helium tank conditioning																		1.5.4		1.5.4
61	Start tank purging																		1.5.5		1.5.5

(a) Engine Contractor minimum requirement.
(b) Must be performed within 6 months after removal from storage controlled environment.

Figure 1-1. Scheduled Authorized Field Activities (Sheet 4 of 6)

Activity Number	Event / Activity	Receiving Inspection	Storage Preparation	Storage	Removal From Storage	Checkout	Installation in Stage	Post-Manufacturing	Storage Preparation	Storage	Removal From Storage	Shipment	Receiving Inspection	Storage Preparation	Storage	Removal From Storage	Inspection and Checkout at VAB	Flight Readiness Test	Countdown Demonstration Test	Countdown Demonstration Test—Securing	Launch Preparation
		IB AND SB											STAGE/VEHICLE (KSC)								
		UNINSTALLED ENGINES						STAGE													
		A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U	V
	SERVICING (cont)																				
62	Start tank conditioning																		1.5.7		1.5.7
63	Start tank depressurization																			1.5.8	
64	Helium tank depressurization																			1.5.9	
65	Thrust chamber jacket drying								(o) 1.5.17					(o) 1.5.17							
66	Fuel system drying								(o) 1.5.18					(o) 1.5.18							
67	Oxidizer system drying								(o) 1.5.19					(o) 1.5.19							
68	Gas generator and oxidizer line drying								(o) 1.5.20					(o) 1.5.20							
69	Gas generator and fuel line drying								(o) 1.5.21					(o) 1.5.21							
70	Start system drying								(o) 1.5.22					(o) 1.5.22							
71	Turbine and exhaust system drying								(o) 1.5.23					(o) 1.5.23							
72	Purge manifold system drying								(o) 1.5.24					(o) 1.5.24							
73	Oxidizer dome and gas generator oxidizer injector drying								(o) 1.5.25					(o) 1.5.25							
74	Pneumatic system drying								(o) 1.5.26					(o) 1.5.26							
75	Calips checkout line drying								(o) 1.5.27					(o) 1.5.27							
76	Gas generator control valve, oxidizer turbine bypass valve, main fuel valve, main oxidizer valve, and on engines incorporating MD300 or MD371 change, mixture ratio control valve drying								(o) 1.5.28					(o) 1.5.28					(a) 1.5.28		
77	Start tank vent-and-relief valve drying								(o) 1.5.29					(o) 1.5.29					(a) 1.5.29		
78	Oxidizer and fuel inlet ducts torsional bellows drying								(o) 1.5.29					(o) 1.5.30							
79	Vent port check valve actuation																		(a) 1.5.31		
79A	Vent port check valve replacement																		(a) 1.5.32		
79B	Thrust chamber temperature transducer heat sink compound replacement																1.53				

(a) Engine Contractor minimum requirement.
(o) Need not be performed if requirements have been satisfied since static test-firing.

Figure 1-1. Scheduled Authorized Field Activities (Sheet 5 of 6)

Activity Number	Event / Activity	HB AND SB											STAGE/VEHICLE (KSC)									
		UNINSTALLED ENGINES						STAGE														
		Receiving inspection	Storage Preparation	Storage	Removal From Storage	Checkout	Installation in Stage	Post-Manufacturing	Storage Preparation	Storage	Removal From Storage	Shipment	Receiving Inspection	Storage Preparation	Storage	Removal From Storage	Inspection and Checkout at VAB	Flight Readiness Test	Countdown Demonstration Test	Countdown Demonstration Test--Securing	Launch Preparation
		A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U	V
	HANDLING																				
80	Oxidizer and fuel inlet duct alinement						1.6.1 (a)	1.6.1 (a)													
81	Engine installation						1.6.2 (a)														
82	Engine cover and closure removal		1.6.13					1.6.13	1.6.13				1.6.15	1.6.13			1.6.16 (a)		1.6.17 (a)		1.6.18 (a)
83	Engine cover and closure installation				1.6.19 (c)			1.6.19 (a)			1.6.19 (c)		1.6.20 (a)			1.6.19 (c)	1.6.22 (a)			1.6.23 (a)	

(a) Engine Contractor minimum requirement.
(c) Must be performed within 14 days after removal from storage controlled environment.

Figure 1-1. Scheduled Authorized Field Activities (Sheet 6 of 6)

Activity Number	Event / Activity	ALL SITES: Engine Removal From Storage	ALL SITES: Uninstalled Engine Shipment	STAGE/VEHICLE (KSC) Launch Countdown Abort: Launch Countdown Recycled	STAGE/VEHICLE (KSC) Launch Countdown Abort: Launch Countdown Rescheduled
		A	B	C	D
	INSPECTIONS				
1	Engine visual	1.1.3			1.1.11
2	Humidity indicators	1.1.15			1.1.15
	ELECTRICAL TESTS				
3	Engine cutoff command			1.2.16	1.2.16
4	Engine cutoff reset				1.2.17
	SHIPMENT PREPARATION				
5	Engine shipment		1.4.3		
	SERVICING				
6	Start tank depressurization			1.5.8	1.5.8
7	Start tank purging			1.5.6	1.5.6
8	Helium tank depressurization			1.5.9	1.5.9
9	Thrust chamber jacket purging			1.5.16	1.5.16
	HANDLING				
10	Engine removal	1.6.3			
11	Engine cover and closure installation	1.6.25			1.6.24

Figure 1-2. Nonscheduled Authorized Field Activities

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1	<u>INSPECTIONS</u>			
1.1.1	<u>ENGINE VISUAL INSPECTION DURING ENGINE RECEIVING INSPECTION AND REMOVAL FROM STORAGE</u>	Visually inspect:		Component removal or system disassembly is not required.
		a. Exposed and accessible portions of engine for:		
		(1) Damage incurred in shipping.	Damage is not allowable.	
		(2) Missing or damaged closures and protective covers:	Missing or damaged closures or protective covers are not allowable.	Protective covers and closures must be removed only as necessary to perform a particular inspection task and must be correctly reinstalled as soon as inspection task is completed.
		(a) Thrust chamber exit closure.		
		(b) Thrust chamber cover.		
		(c) Heat exchanger bellows covers.		
		(d) Four fuel inlet duct bellows covers.		
		(e) Four oxidizer inlet duct bellows covers.		
		(f) Two oxidizer turbine bypass duct bellows covers.		
		(g) Three turbine crossover duct bellows covers.		
		(h) Twelve oxidizer and fuel inlet duct bipod covers.		
		(i) Helium high-pressure relief valve dust cover (engines incorporating MD<u>275</u> or MD<u>362</u> change).		
		(j) Three fuel bleed line covers.		
		(k) Oxidizer turbine seal drain line closure.		
		(l) Fuel turbine seal drain line closure.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.1 (cont)		(m) Oxidizer turbopump primary seal drain line closure.		
		(n) Oxidizer turbopump intermediate seal purge check valve vent line closure.		
		(o) Fuel turbopump primary seal drain line closure.		
		(p) Purge control valve vent line closure.		
		(q) Fluid line interface closures.		
		(r) Electrical harness protective covers.		
		(s) Electrical connector closures.		
		(t) Fuel and oxidizer inlet duct closures.		
		(3) Damaged lockwire.	Damaged, broken,or loose lockwire is not allowable.	
		(4) Damaged identification on lines and flexible hoses.	Obliterated or missing identification is not allowable.	
		b. Gimbal boot for tears, damaged convolutions, and security.	Damage is not allowable.	
		c. ASI for:		
		(1) Spark igniter cable ablative protective covering damage.	See figure 1-3 for damage limits.	
		(2) Fuel and oxidizer line damage.	Damage is not allowable.	
		(3) Clearance between fuel and oxidizer lines and main injector.	Minimum allowable clearance is 0.030 inch.	Instrumentation pickups attached to propellant lines are allowed to contact other surfaces.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.1 (cont)		d. Thrust chamber for damage.	See figure 1-3 for damage limits.	
		e. Injector face for corrosion or damage.	Damage or corrosion is not allowable.	
		f. ECA and primary and auxiliary FI packages for:		
		(1) Pressurization valve swivel nut security.	Looseness of swivel nut is not allowable.	Torque check is not required.
		(2) Protective cap installation.	Missing or improperly installed protective caps are not allowable.	
		(3) Bonding cable damage.	Damage is not allowable.	
		(4) Bonding cable security at termination points.	Looseness at cable termination point is not allowable.	
		g. Start tank insulation cover for damage.	See figure 1-3 for damage limits.	
		h. STDV hose for chafed or damaged braid.	See figure 1-3 for damage limits.	
		i. Oxidizer inlet duct for:		
		(1) Bellows convolution damage.	See figures 1-3 and 1-4 for damage limits.	
		(2) Missing roll pins.	Missing roll pins are not allowable.	
		j. Oxidizer high-pressure duct for rod installation.	Looseness of rods is not allowable.	
		k. Heat exchanger antiflood check valve for proper safetywiring.	Broken or loose lockwire is not allowable.	
		l. Oxidizer turbine exhaust duct and manifold for:		
		(1) Dents.	Damage is not allowable.	
		(2) Convolution distortion.	Distortion is not allowable.	
		(3) Dented bellows.	Dents are not allowable.	
		(4) Verification of accessory mounting pad closure installation.	Missing or improperly installed closure is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.1 (cont)		m. Fuel inlet duct for:		
		(1) Bellows convolution damage.	See figures 1-3 and 1-4 for damage limits.	
		(2) Missing roll pins.	Missing roll pins are not allowable.	
		n. Fuel turbopump insulated volute cover for damage.	See figure 1-3 for damage limits.	
		o. Fuel high-pressure duct and fuel bleed line insulation for cracks, cuts and gouges.	Damage is not allowable.	
		p. Fuel high-pressure duct for rod installation.	Looseness of rods is not allowable.	
		q. Fuel turbine exhaust duct and manifold for:		
		(1) Dents.	Dents are not allowable.	
		(2) Convolution distortion.	Distortion is not allowable.	
		(3) Dented bellows.	Dents are not allowable.	
		(4) Verification of torque access cover installation.	Missing or improperly installed cover is not allowable.	
		r. GG for chafed or damaged braid on propellant inlet lines.	See figure 1-3 for damage limits.	
		s. Vent port check valves for restrictions.	Impaired seating capability of valve is not allowable.	Tape or lockwire must not be over top of valve.
		t. Electrical and instrumentation armored harnesses for:		
		(1) Identification.	Missing or obliterated identification is not allowable.	
		(2) Cleanness.	Dirt, dust, moisture, or foreign particles are not allowable on harness exterior.	
		(3) Exterior armor braid damage.	See figure 1-3 for damage limits.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.1 (cont)		(4) Clearance between harness and lines (tubing) less than 2-inch OD.	Minimum allowable clearance is 1/8 inch.	
		(5) Contact with components or lines that contain or flow hot-gas products.	Direct contact is not allowable except for normal connections (electrical connectors connected to components installed in system).	Indirect contact is acceptable, such as harness contact with a support attached to hot-gas component.
		(6) Contact with sharp edges.	Contact is not allowable with edges having radii that are less than 0.12 inch.	
		(7) Overmold damage.	See figure 1-3 for damage limits.	When determining extent of adhesion or bonded area, overmold must not be flexed, pried, or pulled away from armor braid or other surface on which it is positioned. Heat-shrinkable overmolds are not intended as moisture seals.
		u. Electrical and instrumentation harness connectors for:		Torque relaxation of connectors is a normal occurrence; connectors must not be checked for torque relaxation and must not be retorqued.
		(1) Damaged rubber boots.	See figure 1-3 for damage limits.	
		(2) Identification.	Missing or obliterated identification is not allowable.	
		v. Interface electrical and instrumentation connectors for:		
		(1) Damage.	See figures 1-3 and 1-5 for damage limits.	
		(2) Identification.	Missing or obliterated identification is not allowable.	
		w. Interconnecting pneumatic tubing for:		
		(1) Distorted lines.	Line distortion is not allowable.	
		(2) Leak-test pins missing at flanges.	Missing leak-test pins are not allowable.	
		x. Instrumentation lines for bends at line weld joint to stub-out fitting.	Maximum allowable bend angle at stub-out weld is 10 degrees.	Line must not be straightened.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.1 (cont)		y. Customer connect fluid lines for:		
		(1) Chafed and damaged braid.	See figure 1-3 for damage limits.	
		(2) Customer-connect flange and flange sealing surface damage.	Damage is not allowable.	
		(3) Clearance between lines and adjacent surfaces.	Minimum allowable clearance is 1/8 inch.	Contact is allowable between engine fluid interface lines from the engine support bracket to the customer connect interface.
		z. Lines of less than 2-inch OD for:		
		(1) Clearance between lines and adjacent surfaces.	Minimum allowable clearance is 1/8 inch.	Lines are allowed to contact thermal insulation (including electrical harness boots), oxidizer and fuel turbopumps (if lines are installed as part of turbopump), and engine support bracket.
		(2) Clearance between stage static instrumentation line GG1a and MOV housing.	Minimum allowable clearance is 0.060 inch.	
		(3) Clearance between fuel bleed line and start tank gaseous refill line.	Minimum allowable clearance is 0.030 inch.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.1 (cont)		aa. Lines containing flexible sections for clamps on flexible sections.	Clamps are not allowable on flexible sections of lines.	
		ab. Enter inspection information in Engine Log Book.		
1.1.2	<u>ENGINE VISUAL INSPECTION AFTER INSTALLATION IN STAGE</u>	Visually inspect:		
		a. Exposed and accessible portions of engine for:		Component removal or system disassembly is not required.
		(1) Damage incurred in installation.	Damage is not allowable.	
		(2) Required closures and protective covers installed or damaged.	Missing or damaged closures or protective covers are not allowable.	Protective covers and closures must be removed only as necessary to perform a particular inspection task and must be correctly reinstalled as soon as inspection task is completed.
		b. Thrust chamber and thrust chamber tubes for damage.	See figure 1-3 for damage limits.	
		c. Start tank insulation for damage.	See figure 1-3 for damage limits.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.2 (cont)		d. Electrical and instrumentation harnesses for:		
		(1) Exterior armor braid damage.	See figure 1-3 for damage limits.	
		(2) Overmold damage.	See figure 1-3 for damage limits.	When determining extent of adhesion or bonded area, overmold must not be flexed, pried, or pulled away from armor braid or other surface on which it is positioned. Heat-shrinkable overmolds are not intended as moisture seals.
		(3) Clearance between harness and lines (tubing) less than 2-inch OD.	Minimum allowable clearance is 1/8 inch.	
		(4) Contact with components or lines that contain or flow hot-gas products.	Direct contact is not allowable except for normal connections (electrical connectors connected to components installed in system).	Indirect contact is acceptable, such as harness contact with a support attached to hot-gas component.
		(5) Contact with sharp edges.	Contact is not allowable with edges having radii that are less than 0.12 inch.	
		e. Electrical and instrumentation harness connectors for:		
		(1) Damaged rubber boots.	See figure 1-3 for damage limits.	
		(2) Damaged lockwire.	Damaged, broken, or loose lockwire is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.2 (cont)		f. Interface instrumentation harness connectors for damaged lockwire.	Broken, damaged, or loose lockwire is not allowable.	
		g. Customer-connect fluid lines for:		
		(1) Chafed or damaged braid.	See figure 1-3 for damage limits.	
		(2) Clearance between lines and adjacent surfaces.	Minimum allowable clearance is 1/8 inch.	Contact is allowable between engine fluid interface lines from the engine support bracket to the customer connect interface.
				Contact is allowable between fuel bleed line and heat exchanger helium line from either side of engine-mounted fluid-line interface support bracket to first bend in heat exchanger helium line (SIVB stage).
		h. Oxidizer and fuel inlet ducts for correct alinement.	Total misalinement of all 3 sets of index marks must not exceed 0.066 inch.	Inlet-duct null-point index marks are scribed in 3 places on circumference of duct.
		i. Enter inspection information in Engine Log Book.		
1.1.3	<u>ENGINE VISUAL INSPECTION AFTER REMOVAL FROM STAGE</u>	a. Visually inspect overall engine for required closures and protective covers installed.	Missing closures or protective covers are not allowable.	
		b. Enter inspection information in Engine Log Book.		
1.1.4	<u>ENGINE VISUAL INSPECTION DURING STAGE RECEIVING INSPECTION</u>	Visually inspect:		
		a. Exposed and accessible portions of engine for:		Component removal or system disassembly is not required.
		(1) Damage incurred in shipping.	Damage is not allowable.	
		(2) Required closures and protective covers installed or damaged.	Missing or damaged closures or protective covers are not allowable.	Protective covers and closures must be removed only as necessary to perform a particular inspection task and must be correctly reinstalled as soon as inspection task is completed.
		(3) Damaged lockwire.	Damaged, broken, or loose lockwire is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.4 (cont)		(4) Damaged identification on lines and flexible hoses.	Obliterated or missing identification is not allowable.	The high-pressure relief valve dust cover (engines incorporating MD272 change) does not have to be installed after stage receiving inspection at KSC.
		(5) Damage incurred in handling.	Damage is not allowable.	
		b. Gimbal boot for tears, damaged convolutions and security.	Damage is not allowable.	
		c. ASI for:		
		(1) Spark igniter cable ablative protective covering damage.	See figure 1-3 for damage limits.	
		(2) Fuel and oxidizer lines damage.	Damage is not allowable.	
		(3) Clearance between fuel and oxidizer lines and main injector.	Minimum allowable clearance is 0.030 inch.	Instrumentation pickups attached to propellant line are allowed to contact other surfaces.
		d. Thrust chamber for damage.	See figure 1-3 for damage limits.	
		e. Injector face for corrosion or damage.	Damage or corrosion is not allowable.	
		f. ECA and primary and auxiliary FI packages for:		
		(1) Pressurization valve swivel nut security.	Looseness of swivel nut is not allowable.	Torque check is not required.
		(2) Protective cap installation.	Missing or uninstalled protective caps are not allowable.	
		(3) Bonding cable damage.	Damage is not allowable.	
		(4) Bonding cable security at termination points.	Looseness at cable termination point is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.4 (cont)		g. Start tank insulation cover for damage.	See figure 1-3 for damage limits.	
		h. STDV hose for chafed or damaged braid.	See figure 1-3 for damage limits.	
		i. Oxidizer inlet duct for:		
		(1) Bellows convolution damage.	See figures 1-3 and 1-4 for damage limits.	
		(2) Missing roll pins.	Missing roll pins are not allowable.	
		j. Oxidizer high-pressure duct rod installation.	Looseness of rods is not allowable.	
		k. Oxidizer propellant system insulation for cracks, cuts, and gouges (SII-stage engines).	Cracks, cuts, or gouges are not allowable.	
		l. Heat exchanger antiflood check valve for proper safetywiring (SII-stage engines).	Broken or loose lockwire is not allowable.	
		m. Oxidizer turbine exhaust duct and manifold for:		
		(1) Dents.	Damage is not allowable.	
		(2) Convolution distortion.	Distortion is not allowable.	
		(3) Dented bellows.	Dents are not allowable.	
		(4) Accessory mounting pad closure installation (SII-stage center engine).	Missing or uninstalled closure is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.4 (cont)		n. Fuel inlet duct for:		
		(1) Convolution damage.	See figures 1-3 and 1-4 for damage limits.	
		(2) Missing roll pins.	Missing roll pins are not allowable.	
		o. Fuel turbopump insulated volute cover for damage.	See figure 1-3 for damage limits.	
		p. Fuel high pressure duct insulation for cracks and cuts.	Damage is not allowable.	
		q. Fuel bleed line insulation for damage.	See figure 1-3 for damage limits.	
		r. Fuel high-pressure duct for rod installation.	Looseness of rods is not allowable.	
		s. Fuel turbine exhaust duct and manifold for:		
		(1) Dents.	Dents are not allowable.	
		(2) Convolution distortion.	Distortion is not allowable.	
		(3) Dented bellows.	Dents are not allowable.	
		(4) Verification of torque access cover installation.	Missing or improperly installed cover is not allowable.	
		t. Fuel turbopump seal drain and oxidizer turbopump seal drain lines for protective caps.	Missing or improperly installed protective caps are not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.4 (cont)		u. GG for chafed or damaged braid on propellant inlet lines.	See figure 1-3 for damage limits.	
		v. Vent port check valves for restrictions.	Impaired sealing capability of valve is not allowable.	Tape or lockwire must not be over top of valve.
		w. Electrical and instrumentation armored harnesses for:		
		(1) Identification.	Missing or obliterated identification is not allowable.	
		(2) Exterior armor braid damage.	See figure 1-3 for damage limits.	
		(3) Clearance between harness and lines (tubing) less than 2-inch OD.	Minimum allowable clearance is 1/8 inch.	
		(4) Contact with components or lines that contain or flow hot-gas products.	Direct contact is not allowable except for normal connections (electrical connectors connected to components installed in system).	Indirect contact is acceptable, such as harness contact with a support attached to hot-gas component.
		(5) Contact with sharp edges.	Contact is not allowable with edges having radii that are less than 0.12 inch.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.4 (cont)		(6) Overmold damage.	See figure 1-3 for damage limits.	When determining extent of adhesion or bonded area, overmold must not be flexed, pried, or pulled away from armor braid or other surface on which it is positioned. Heat-shrinkable overmolds are not intended as moisture seals.
		x. Electrical and instrumentation harness connectors for:		
		(1) Damaged rubber boots.	See figure 1-3 for damage limits.	
		(2) Identification.	Missing or obliterated identification is not allowable.	
		y. Interface electrical and instrumentation connectors for identification.	Missing or obliterated identification is not allowable.	
		z. Interconnecting pneumatic tubing for:		
		(1) Distorted lines.	Line distortion is not allowable.	
		(2) Leak-test pins missing at flanges.	Missing leak-test pins are not allowable.	
		aa. Instrumentation lines for bends at line weld joint to stub-out fitting.	Maximum allowable bend angle at stub-out weld is 10 degrees.	Line must not be straightened.
		ab. Customer-connect fluid lines for:		
		(1) Chafed and damaged braid.	See figure 1-3 for damage limits.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.4 (cont)		(2) Clearance between lines and adjacent surfaces.	Minimum allowable clearance is 1/8 inch.	Contact is allowable between engine fluid interface lines from the engine support bracket to the customer connect interface.
				Contact is allowable between fuel bleed line and heat exchanger helium line from either side of engine-mounted fluid-line interface support bracket to first bend in heat exchanger helium line (SIVB stage).
		ac. Lines of less than 2-inch OD for:		
		(1) Clearance between lines and adjacent surfaces.	Minimum allowable clearance is 1/8 inch.	Lines are allowed to contact thermal insulation (including electrical harness boots), oxidizer and fuel turbopumps (if lines are installed as part of turbopump), and engine support bracket.
		(2) Clearance between stage static instrumentation line GG1a and main oxidizer valve housing.	Minimum allowable clearance is 0.060 inch.	
		(3) Clearance beween fuel bleed line and start tank gaseous refill line.	Minimum allowable clearance is 0.030 inch.	
		ad. Clamps on lines containing flexible sections.	Clamps are not allowable on flexible section of lines.	
		ae. Enter inspection information in Engine Log Book.		

1.1.5 through 1.1.8 (Deleted)

All data on pages 1-25 through 1-40 deleted.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.5	ENGINE VISUAL INSPECTION FOR STAGE STATIC TEST	Visually inspect engine during preparation phase of test in accordance with paragraph 1.1.5.1, and visually inspect engine as close to static-firing test as possible in accordance with paragraph 1.1.5.2. Observe engine propellant system after propellant loading in accordance with paragraph 1.1.5.3.		Inspections in paragraphs 1.1.5.1 and 1.1.5.2 may be interchanged as necessary for test conditions as long as requirements and limits are not invalidated by so doing.
1.1.5.1	Engine Visual Inspection During Stage Static-Test Preparation	Visually inspect:		
		a. Exposed and accessible portions of engine for:		Component removal or system disassembly is not required.
		(1) Damaged lockwire.	Damaged, broken, or loose lockwire is not allowable.	
		(2) Identification on components, lines, and flexible hoses.	Obliterated or missing identification is not allowable.	
		(3) Required closures and protective covers installed until scheduled time for their removal for engine static firing.	Missing or improperly installed closures or protective covers are not allowable.	Closures removed during inspection must be correctly reinstalled at end of inspection.
		(4) Cleanness and moisture.	Dirt, foreign objects, or moisture is not allowable.	
		(5) Damage incurred in handling.	Damage is not allowable.	
		b. Gimbal boot for tears, damaged convolutions, and security.	Damage is not allowable.	
		c. ASI for:		
		(1) Spark igniter cable ablative protective covering damage.	See figure 1-3 for damage limits.	
		(2) Fuel and oxidizer lines damage.	Damage is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.5.1 (cont)		(3) Clearance between fuel and oxidizer lines and main injector.	Minimum allowable clearance is 0.030 inch.	Instrumentation pickups attached to propellant lines are allowed to contact other surfaces.
	d.	Thrust chamber for damage.	See figure 1-3 for damage limits.	
	e.	ECA and primary and auxiliary FI packages for:		
		(1) Pressurization valve swivel nut security.	Looseness of swivel nut is not allowable.	Torque check is not required.
		(2) Protective cap installation.	Missing or improperly installed protective caps are not allowable.	
		(3) Bonding cable damage.	Damage is not allowable.	
		(4) Bonding cable security at termination points.	Looseness at cable termination point is not allowable.	
	f.	Start tank insulation cover for damage.	See figure 1-3 for damage limits.	
	g.	STDV hose for chafed or damaged braid.	See figure 1-3 for damage limits.	
	h.	Oxidizer inlet duct for:		
		(1) Bellows convolution damage.	See figures 1-3 and 1-4 for damage limits.	
		(2) Missing roll pins.	Missing roll pins are not allowable.	
	i.	Oxidizer high-pressure duct rod installation.	Looseness of rods is not allowable.	
	j.	Oxidizer propellant system insulation for cracks, cuts, and gouges (SII-stage engines).	Cracks, cuts, or gouges are not allowable.	
	k.	Heat exchanger antiflood check valve for proper safetywiring (SII-stage engines).	Broken or loose lockwire is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.5.1 (cont)		l. Oxidizer turbine exhaust duct and manifold for:		
		(1) Dents.	Damage is not allowable.	
		(2) Convolution distortion.	Distortion is not allowable.	
		(3) Dented bellows.	Dents are not allowable.	
		(4) Accessory mounting pad closure installation (SII-stage center engine).	Missing or uninstalled closure is not allowable.	
		m. Fuel inlet duct for:		
		(1) Convolution damage.	See figures 1-3 and 1-4 for damage limits.	
		(2) Missing roll pins.	Missing roll pins are not allowable.	
		n. Fuel turbopump insulated volute cover for damage.	See figure 1-3 for damage limits.	
		o. Fuel high-pressure duct insulation for cracks and cuts.	Damage is not allowable.	
		p. Fuel bleed line insulation for damage.	See figure 1-3 for damage limits.	
		q. Fuel high-pressure duct for rod installation.	Looseness of rods is not allowable.	
		r. Fuel turbine exhaust duct and manifold for:		
		(1) Dents.	Dents are not allowable.	
		(2) Convolution distortion.	Distortion is not allowable.	
		(3) Dented bellows.	Dents are not allowable.	
		(4) Verification of torque access cover installation.	Missing or improperly installed cover is not allowable.	
		s. Fuel turbine exhaust duct manifold cavity for foreign objects and water.	Foreign objects and water are not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.5.1 (cont)		t. GG for chafed or damaged braid on propellant inlet lines.	See figure 1-3 for damage limits.	
		u. Vent port check valves for restrictions.	Impaired seating capability of valve is not allowable.	Tape or lockwire must not be over top of valve.
		v. Electrical and instrumentation armored harnesses for:		
		(1) Identification.	Missing or obliterated identification is not allowable.	
		(2) Exterior armor braid damage.	See figure 1-3 for damage limits.	
		(3) Clearance between harness and lines (tubing) less than 2-inch OD.	Minimum allowable clearance is 1/8 inch.	
		(4) Contact with components or lines that contain or flow hot-gas products.	Direct contact is not allowable except for normal connections (electrical connectors connected to components installed in system).	Indirect contact is acceptable, such as harness contact with a support attached to hot-gas component.
		(5) Contact with sharp edges.	Contact is not allowable with edges having radii that are less than 0.12 inch.	
		(6) Overmold damage.	See figure 1-3 for damage limits.	When determining extent of adhesion or bonded area, overmold must not be flexed, pried, or pulled away from armor braid or other surface on which it is positioned. Heat-shrinkable overmolds are not intended as moisture seals.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.5.1 (cont)		w. Electrical and instrumentation harness connectors for:		Torque relaxation of connectors is a normal occurrence; connectors must not be checked for torque relaxation and must not be retorqued.
		(1) Damaged rubber boots.	See figure 1-3 for damage limits.	
		(2) Identification.	Missing or obliterated identification is not allowable.	
		x. Interface electrical and instrumentation connectors for identification.	Missing or obliterated identification is not allowable.	Torque relaxation of connectors is a normal occurrence; connectors must not be checked for torque relaxation and must not be retorqued.
		y. Interconnecting pneumatic tubing for:		
		(1) Distorted lines.	Line distortion is not allowable.	
		(2) Leak-test pins missing at flanges.	Missing leak-test pins are not allowable.	
		z. Instrumentation lines for bends at line weld joint to stub-out fitting.	Maximum allowable bend angle at stub-out weld is 10 degrees.	Line must not be straightened.
		aa. Customer-connect fluid lines for:		
		(1) Chafed and damaged braid.	See figure 1-3 for damage limits.	
		(2) Clearance between lines and adjacent surfaces.	Minimum allowable clearance is 1/8 inch.	Contact is allowable between flexible section of fluid interface lines located between support bracket and customer-connect fluid interface panel. Contact is allowable between fuel bleed line and heat exchanger helium line from either side of engine-mounted fluid-line interface support bracket to first bend in heat exchanger helium line (SIVB stage).

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.5.1 (cont)		ab. Lines of less than 2-inch OD for:		
		(1) Clearance between lines and adjacent surfaces.	Minimum allowable clearance is 1/8 inch.	Lines are allowed to contact thermal insulation (including electrical harness boots), oxidizer and fuel turbopumps (if lines are installed as part of turbopump), and engine support bracket.
		(2) Clearance between stage static instrumentation line GG1a and main oxidizer valve housing.	Minimum allowable clearance is 0.060 inch.	
		(3) Clearance between fuel bleed line and start tank gaseous refill line.	Minimum allowable clearance is 0.030 inch.	
		ac. Clamps on lines containing flexible sections.	Clamps are not allowable on flexible section of lines.	
		ad. Enter inspection information in Engine Log Book.		
1.1.5.2	<u>Engine Visual Inspection Before Static-Test Firing</u>	Visually inspect:		
		a. Overall engine for verification of removal of the following test plates, plugs, and adapters used in leak and function testing:	Test plates, plugs, and adapters must be removed.	Engine connections affected by test equipment must be correctly reinstalled/reconnected.
		(1) Thrust chamber throat plug.		
		(2) Plate between heat exchanger and exhaust manifold.		
		(3) Plate between OTBV and exhaust duct.		
		(4) Plate on fuel turbine torque access; verify that plug has been reinstalled.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.5.2 (cont)		(5) Plate on OTBV closing control port.		
		(6) Plate between OTBV and OTBV opening control line.		
		(7) Plate between purge control valve and valve inlet line.		
		(8) Plate between pneumatic accumulator and accumulator hose.		
		(9) Plate between fuel bleed valve control port and control line.		
		(10) Plate between oxidizer bleed valve control port and conttol line.		
		(11) Plate between STDV bleed port and bleed line.		
		(12) Plate between purge control valve vent port and vent line.		
		(13) Test plate on GG oxidizer purge line flange downstream of check valve.		
		(14) Test plug in oxidizer injector purge test port CN1; verify that proper plug has been reinstalled.		
		(15) Test plate on FUEL PUMP DRAIN customer connect.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.5.2 (cont)		(16) Test adapter on oxidizer turbine seal cavity drain line (17) Test adapter on fuel turbine seal cavity drain line (18) Test adapter in fitting between fuel turbopump and fuel turbopump drain check valve; verify that plug has been reinstalled (19) Vent adapter in boss in MFV closing control line; verify that vent port relief valve has been reinstalled. (20) Verification that oxidizer turbopump torque access cover plate has been reinstalled		
		b. Overall engine for verification of removal of covers and closures	Except for designated electrical harnesses and connectors, all engine covers and closures must be removed before static-firing the engine.	The following covers and closures are not required to be removed for engine static firing: a. Twelve electrical harness protective covers (located between clamping block and customer-connect panel). aA. Twelve electrical harness protective covers (located between electrical harness clamping blocks). b. Closures on the following electrical connectors: (1) J160 (2) J163

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.5.2 (cont)				(3) J180 (on engines not incorporating MD320 or MD351 change).
				(4) J110A and J111A (on engines not incorporating MD150, MD280, or MD281 change).
				(5) J161 (on engines incorporating MD199 change).
				(6) P161 (on engines incorporating MD172 change but not incorporating MD185 change).
				(7) J22 (on engines incorporating MD160 change).
				(8) P157 (on engines incorporating MD100 change).
		c. Oxidizer turbopump primary seal drain line (at thrust chamber exit) for verification of removal of burst diaphragm.	Burst diaphragm must be removed.	On engines incorporating MD301, MD302, MD322, or MD323 change.
		d. Fuel turbine cavity double diaphragm area for water (area between fuel turbine manifold torus "hat section" over expansion joint, between fuel turbine manifold and turbopump housing).	Water is not allowable.	Required before loading propellants; refer to paragraph 1.5.1.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.5.2 (cont)		e. Fuel turbine exhaust duct manifold cavity for foreign objects and water.	Water or foreign objects are not allowable.	Required before loading propellants; refer to paragraph 1.5.1.
		f. The following external surfaces of engine for moisture:	Moisture is not allowable on external surfaces.	Required before loading propellants; refer to paragraph 1.5.1.
		(1) Oxidizer inlet duct.		
		(2) Fuel inlet duct.		
		(3) Gimbal bearing/dome depression area on thrust chamber.		
		(4) Cavity between fuel manifold and thrust chamber.		
		(5) Cavity between turbine exhaust manifold and thrust chamber.		
		g. Enter inspection information in Engine Log Book.		
1.1.5.3	<u>Engine Propellant System Observation After Propellant Loading</u>	a. Observe oxidizer propellant system for evidence of leakage.	Visible propellant leakage is not allowable.	
		b. Observe fuel propellant system for evidence of leakage.	Visible propellant leakage is not allowable.	
		c. Observe oxidizer and fuel turbine seal drain lines for liquid leakage.	Liquid leakage is not allowable.	
		d. Enter inspection information in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.6	<u>ENGINE VISUAL INSPECTION FOR STAGE STATIC-TEST ABORT AFTER ENGINE START</u>	a. Visually inspect main injector hardware for frost and moisture. b. Enter inspection information in Engine Log Book.	Frost or moisture is not allowable.	On SII-stage engines not supplied with facility line for oxidizer dome purge, this inspection is required after thrust chamber jacket gaseous nitrogen purge in paragraph 1.5.15.1. On SIVB-stage engines and SII-stage engines supplied with facility purge line, if inspection cannot be performed, the purge operations in paragraph 1.5.13 (SIVB) or paragraph 1.5.15.2 (SII alternate) must be substituted.
1.1.7	<u>THRUST CHAMBER INJECTOR INSPECTION</u>			This requirement applies after mainstage static-firing test if injector damage is suspected as a result of abnormal conditions, such as hard start or MOV lip seal leakage. Requirement does not apply between successive static-firing tests conducted to demonstrate restart capabilities. Injector must be at ambient temperature of 40° to 100°F. Thrust chamber exit closure removed for this inspection must be correctly reinstalled, with desiccant, at conclusion of inspection.
		a. Inspect the 85 outboard oxidizer injector posts for spacing between tip of oxidizer post and fuel cavity wall (annulus space) on side of each oxidizer post toward center of injector face.	Annulus space must be less than 0.0520 inch.	If annulus space exceeds limit on any oxidizer posts, those posts must be measured in accordance with requirements in step b. Posts are numbered 1 through 85, clockwise when facing injector. Post No. 1 is located in the only straight-line radial row of orifices from center to periphery of injector.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.7 (cont)		b. Measure annulus space on side of oxidizer post toward center of injector face and also on opposite side in line with center on outside edge of injector on posts that exceed limit in step a.	Annulus space on side of post toward center of injector face must not exceed annulus space on side of post on outer edge of injector by more than 0.010 inch.	
		c. Enter inspection information in Engine Log Book.		
1.1.8	<u>ENGINE VISUAL INSPECTION DURING STAGE STATIC-TEST SECURING</u>	Visually inspect:		
		a. Exposed and accessible portions of engine for:		Component removal or system disassembly is not required.
		(1) Damaged lockwire.	Damaged, broken, or loose lockwire is not allowable.	
		(2) Identification on components, lines, and flexible hoses.	Obliterated or missing identification is not allowable.	
		(3) Required closures and protective covers installed or damaged.	Missing or damaged closures or protective covers are not allowable.	Protective covers and closures must be removed only as necessary to perform a particular inspection task and must be correctly reinstalled as soon as inspection task is completed.
		(4) Cleanness and moisture.	Dirt, foreign objects, or moisture is not allowable.	
		b. Gimbal boot for tears, damaged convolutions, and security.	Damage is not allowable.	
		c. ASI for:		
		(1) Spark igniter cable ablative protective covering damage.	See figure 1-3 for damage limits.	
		(2) Fuel and oxidizer line damage.	Damage is not allowable.	
		(3) Clearance between fuel and oxidizer lines and main injector.	Minimum allowable clearance is 0.030 inch.	Instrumentation pickups attached to propellant lines are allowed to contact other surfaces.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.8 (cont)		d. Thrust chamber and tubes for damage.	See figure 1-3 for damage limits.	
		e. Thrust chamber injector for evidence of moisture.	Moisture is not allowable.	
		f. ECA and primary and auxiliary FI packages for:		
		(1) Pressurization valve swivel nut security.	Looseness of swivel nut is not allowable.	Torque check is not required.
		(2) Protective cap installation.	Missing or improperly installed protective caps are not allowable.	
		(3) Bonding cable secure at termination points.	Looseness at cable termination point is not allowable.	
		g. Start tank insulation cover for:		
		(1) Damage.	See figure 1-3 for damage limits.	
		(2) Burned areas.	Burned areas are not allowable.	
		h. STDV hose for chafed or damaged braid.	See figure 1-3 for damage limits.	
		i. Oxidizer inlet duct for:		Insulation, if installed, must not be removed for inspection.
		(1) Bellows convolution damage.	See figures 1-3 and 1-4 for damage limits.	
		(2) Missing roll pins.	Missing roll pins are not allowable.	
		(3) Proper installation of bipod retaining pins.	Each retaining pin must extend through and protrude at least 1/16 inch on each side of bipod pivot pin.	
		j. Oxidizer inlet duct for correct alinement.	Total misalinement of all 3 sets of index marks must not exceed 0.066 inch.	Inlet duct null point index marks are scribed in 3 places on circumference of duct.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.8 (cont)		k. Oxidizer propellant system insulation for cracks, cuts, and gouges (SII-stage engines).	Cracks, cuts, or gouges are not allowable.	
		l. Oxidizer high-pressure duct rods for installation.	Looseness of rods is not allowable.	
		m. Heat exchanger antiflood check valve for proper safetywiring (SII-stage engines).	Broken or loose lockwire is not allowable.	
		n. Oxidizer turbine exhaust duct and manifold for:		
		(1) Dents.	Damage is not allowable.	
		(2) Convolution distortion.	Distortion is not allowable.	
		(3) Dented bellows.	Dents are not allowable.	
		(4) Accessory mounting pad closure installation (SII-stage center engine).	Missing or uninstalled closure is not allowable.	
		o. Fuel inlet duct for:		Insulation, if installed, must not be removed for inspection.
		(1) Convolution damage.	See figures 1-3 and 1-4 for damage limits.	
		(2) Missing roll pins.	Missing roll pins are not allowable.	
		(3) Distorted convolutions.	Maximum allowable space between convolutions on vacuum jacket bellows is 0.060 inch.	Engine must be within ±2 degrees of null position.
		(4) Proper installation of bipod retaining pins.	Each retaining pin must extend through and protrude at least 1/16 inch on each side of bipod pivot pin.	
		p. Fuel inlet duct for correct alinement.	Total misalinement of all 3 sets of index marks must not exceed 0.066 inch.	Inlet duct null point index marks are scribed in 3 places on circumference of duct.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.8 (cont)		q. Fuel turbopump insulated volute cover for damage.	See figure 1-3 for damage limits.	
		r. Fuel high-pressure duct insulation for cracks and cuts.	Damage is not allowable.	
		s. Fuel bleed line insulation for damage.	See figure 1-3 for damage limits.	
		t. Fuel high-pressure duct for rod installation.	Looseness of rods is not allowable.	
		u. Fuel turbine exhaust duct and manifold for:		
		(1) Dents.	Dents are not allowable.	
		(2) Convolution distortion.	Distortion is not allowable.	
		(3) Dented bellows.	Dents are not allowable.	
		(4) Verification of torque access cover installation.	Missing or improperly installed cover is not allowable.	
		v. GG for:		
		(1) Chafed or damaged braid on propellant inlet lines.	See figure 1-3 for damage limits.	
		(2) Exterior for signs of hot spots, eroded areas, and obvious damage.	Hot spots, erosion, or damage is not allowable.	
		w. Vent port check valves for restrictions.	Impaired seating capability of valve is not allowable.	Tape or lockwire must not be over top of valve.
		x. Electrical and instrumentation armored harnesses for:		
		(1) Identification.	Missing or obliterated identification is not allowable.	
		(2) Exterior armor braid damage.	See figure 1-3 for damage limits.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.8 (cont)		(3) Clearance between harness and lines (tubing) less than 2-inch OD.	Minimum allowable clearance is 1/8 inch.	
		(4) Contact with components or lines that contain or flow hot-gas products.	Direct contact is not allowable except for normal connections (electrical connectors connected to components installed in system).	Indirect contact is acceptable, such as harness contact with a support attached to hot-gas component.
		(5) Contact with sharp edges.	Contact is not allowable with edges having radii that are less than 0.12 inch.	
		(6) Overmold damage.	See figure 1-3 for damage limits.	When determining extent of adhesion or bonded area, overmold must not be flexed, pried, or pulled away from armor braid or other surface on which it is positioned. Heat-shrinkable overmolds are not intended as moisture seals.
		y. Electrical and instrumentation harness connectors for:		
		(1) Damaged rubber boots.	See figure 1-3 for damage limits.	
		(2) Identification.	Missing or obliterated identification is not allowable.	
		z. Interface electrical and instrumentation connectors for identification.	Missing or obliterated identification is not allowable.	
		aa. Interconnecting pneumatic tubing for:		
		(1) Distorted lines.	Line distortion is not allowable.	
		(2) Leak-test pins missing at flanges.	Missing leak-test pins are not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.9	ENGINE VISUAL INSPECTION AT VAB AND STAGE REMOVAL FROM STORAGE	Visually inspect:		
		a. Exposed and accessible portions of engine for:		Component removal or system disassembly is not required.
		(1) Damaged lockwire.	Damaged, broken, or loose lockwire is not allowable.	
		(2) Identification on component, lines, and flexible hoses.	Obliterated or missing identification is not allowable.	
		(3) Required closures and protective covers installed or damaged.	Missing or damaged closures or protective covers are not allowable.	Protective covers and closures must be removed only as necessary to perform a particular inspection task and must be correctly reinstalled as soon as inspection task is completed. The high-pressure relief valve dust cover (engines incorporating MD272 change) does not have to be installed after stage receiving inspection at KSC.
		b. Gimbal boot for tears, damaged convolutions, and security.	Damage is not allowable.	
		c. ASI for:		
		(1) Spark igniter cable ablative protective covering damage.	See figure 1-3 for damage limits.	
		(2) Fuel and oxidizer line damage.	Damage is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.9 (cont)		(3) Clearance between fuel and oxidizer lines and main injector.	Minimum allowable clearance is 0.030 inch.	Instrumentation pickups attached to propellant lines are allowed to contact other surfaces.
		d. ECA and primary and auxiliary FI packages for:		
		(1) Pressurization valve swivel nut security.	Looseness of swivel nut is not allowable.	Torque check is not required.
		(2) Protective cap installation.	Missing or improperly installed protective cap is not allowable.	
		(3) Bonding cable secure at termination points.	Looseness at cable termination point is not allowable.	
		e. ECA and ECA support rod insulation for damage.	Damage is not allowable.	
		f. Start tank insulation cover for damage.	See figure 1-3 for damage limits.	
		g. STDV hose for chafed or damaged braid.	See figure 1-3 for damage limits.	
		h. Oxidizer high-pressure duct rod for installation.	Looseness of rod is not allowable.	
		i. Heat exchanger antiflood check valve for proper safetywiring (SII-stage engines).	Broken or loose safetywire is not allowable.	
		j. Oxidizer inlet duct for:		Insulation must not be removed for inspection.
		(1) Bellows convolution damage.	See figures 1-3 and 1-4 for damage limits.	
		(2) Missing roll pins.	Missing roll pins are not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.9 (cont)		k. Oxidizer turbine exhaust duct and manifold for:		
		(1) Dents.	Dents are not allowable.	
		(2) Convolution distortion.	Distortion is not allowable.	
		(3) Dented bellows.	Dents are not allowable.	
		(4) Accessory mounting pad closure installation (SII-stage center engine).	Missing or improperly installed closure is not allowable.	
		l. Fuel inlet duct for:		Insulation must not be removed for inspection.
		(1) Bellows convolution damage.	See figures 1-3 and 1-4 for damage limits.	
		(2) Missing roll pins.	Missing roll pins are not allowable.	
		m. Fuel turbopump insulated volute cover for damage.	See figure 1-3 for damage limits.	
		n. Fuel high-pressure duct insulation for cracks and cuts.	Damage is not allowable.	
		o. Fuel bleed line insulation for damage.	See figure 1-3 for damage limits.	
		p. Fuel high-pressure duct rods for installation.	Looseness of rods is not allowable.	
		q. MFV insulation for damage (SII-stage center engine).	Damage is not allowable.	
		r. OTBV insulation for damage (SII-stage outboard engines).	Damage is not allowable.	
		s. Fuel turbine exhaust duct and manifold for:		
		(1) Dents.	Dents are not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.9 (cont)		(2) Convolution distortion.	Distortion is not allowable.	
		(3) Dented bellows.	Dents are not allowable.	
		(4) Verification of torque access cover installation.	Missing or improperly installed cover is not allowable.	
		t. GG for chafed or damaged braid on propellant inlet lines.	See figure 1-3 for damage limits.	
		u. Fast-shutdown valve insulation for damage (SII-stage outboard engines).	Damage is not allowable.	
		v. Vent port check valves for restrictions.	Impaired seating capability of valve is not allowable.	Tape or lockwire must not be over top of valve.
		w. Electrical and instrumentation armored harness for:		
		(1) Identification.	Missing or obliterated identification is not allowable.	
		(2) Exterior armor braid damage.	See figure 1-3 for damage limits.	
		(3) Clearance between harness and lines (tubing) less than 2-inch OD.	Minimum allowable clearance is 1/8 inch.	
		(4) Contact with components or lines that contain or flow hot-gas products.	Direct contact is not allowable except for normal connections (electrical connectors connected to components installed in system).	Indirect contact is acceptable, such as harness contact with a support attached to hot-gas component.
		(5) Contact with sharp edges.	Contact is not allowable with edges having radii that are less than 0.12 inch.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.9 (cont)		(6) Overmold damage.	See figure 1-3 for damage limits.	When determining extent of adhesion or bonded area, overmold must not be flexed, pried, or pulled away from armor braid or other surface on which it is positioned. Heat-shrinkable overmolds are not intended as moisture seals.
		x. Electrical and instrumentation harness connectors for:		
		(1) Damaged rubber boots.	See figure 1-3 for damage limits.	
		(2) Identification.	Missing or obliterated identification is not allowable.	
		y. Interface electrical and instrumentation connectors for identification.	Missing or obliterated identification is not allowable.	
		z. Interconnecting pneumatic tubing for:		
		(1) Distorted lines.	Line distortion is not allowable.	
		(2) Leak-test pins missing at flanges	Missing leak-test pins are not allowable.	
		aa. Instrumentation lines for bends at line weld joint to stub-out fitting.	Maximum allowable bend angle at stub-out weld is 10 degrees.	Line must not be straightened.
		ab. Customer-connect fluid lines for:		
		(1) Chafed and damaged braid.	See figure 1-3 for damage limits.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.9 (cont)		(2) Clearance between lines and adjacent surfaces.	Minimum allowable clearance is 1/8 inch.	Contact is allowable between engine fluid interface lines from the engine support bracket to the customer connect interface.
				Contact is allowable between fuel bleed line and heat exchanger helium line from either side of engine-mounted fluid-line interface support bracket to first bend in heat exchanger helium line (SIVB stage).
		ac. Lines of less than 2-inch OD for:		
		(1) Clearance between lines and adjacent surfaces.	Minimum allowable clearance is 1/8 inch.	Lines are allowed to contact thermal insulation (including electrical harness boots), oxidizer and fuel turbopumps (if lines are installed as part of turbopump), and engine support bracket.
		(2) Clearance between stage static instrumentation line GG1a and main oxidizer valve housing.	Minimum allowable clearance is 0.060 inch.	
		(3) Clearance between fuel bleed line and start tank gaseous refill line.	Minimum allowable clearance is 0.030 inch.	
		ad. Clamps on lines containing flexible sections.	Clamps are not allowable on flexible section of lines.	
		ae. Engine for verification of removal of test plates used in leak and function testing.	Installed test plates are not allowable.	
		af. Enter inspection information in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.10	ENGINE VISUAL INSPECTION FOR COUNTDOWN DEMONSTRATION TEST	Visually inspect:		
		a. Overall engine for verification of installation and security of covers and closures before scheduled removal.	Required covers and closures must be correctly installed and secured until scheduled time for their removal for countdown demonstration test.	The high-pressure relief valve dust cover (engines incorporating MD272 change) does not have to be installed after stage receiving inspection at KSC.
		b. Overall engine for verification of removal of covers and closures, when scheduled.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.10	<u>ENGINE VISUAL INSPECTION FOR COUNTDOWN DEMONSTRATION TEST</u>	Visually inspect:		
		a. Overall engine for verification of installation and security of covers and closures before scheduled removal.	Required covers and closures must be correctly installed and secured until scheduled time for their removal for countdown demonstration test.	Closures and covers removed during inspection must be correctly reinstalled at end of inspection.
		b. Overall engine for verification of removal of covers and closures, when scheduled.	Except for designated electrical harnesses and connectors, all engine covers and closures must be removed before countdown demonstration test.	The following covers and closures are not required to be removed for countdown demonstration test: a. Twenty-four electrical harness protective covers (located between engine clamping blocks and customer connect panel). b. Closures on the following electrical connectors: (1) J160. (2) J163. (3) J180 (on engines not incorporating MD<u>320</u> or MD<u>351</u> change). (4) J161 (on engines incorporating MD<u>199</u> change). (5) P161 (on engines incorporating MD<u>172</u> change but not incorporating MD<u>185</u> change). (6) J22 (on engines incorporating MD<u>160</u> change).

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.10 (cont)		c. Oxidizer propellant system insulation for cracks, cuts, and gouges (SII-stage engines).	Damage is not allowable.	
		d. Enter inspection information in Engine Log Book.		
1.1.11	<u>ENGINE VISUAL INSPECTION FOR COUNTDOWN DEMONSTRATION TEST SECURING</u>	Visually inspect:		
		a. Exposed and accessible portions of engine for cleanness and moisture.	Dirt, foreign objects, or moisture is not allowable.	Component removal or system disassembly is not required.
		b. Thrust chamber insulation for damage.	See figure 1-3 for damage limits.	
		c. Thrust chamber injector for:		
		(1) Moisture.	Moisture is not allowable.	
		(2) Damage and corrosion on injector face.	Damage or corrosion is not allowable.	
		d. Start tank insulation for damage.	See figure 1-3 for damage limits.	
		e. Oxidizer propellant system insulation for cracks, cuts, and gouges (SII-stage engines).	Damage is not allowable.	
		f. Oxidizer inlet duct for bellows convolution damage.	See figures 1-3 and 1-4 for damage limits.	Insulation must not be removed for inspection.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.11 (cont)		g. Fuel inlet duct for:		Insulation must not be removed for inspection.
		(1) Bellows convolution damage.	See figures 1-3 and 1-4 for damage limits.	
		(2) Missing roll pins.	Missing roll pins are not allowable.	
		(3) Distorted convolutions.	Minimum allowable space between convolutions on vacuum jacket bellows is 0.060 inch.	Engine must be within ±2 degrees of null position.
		h. Fuel high-pressure duct insulation for cracks and cuts.	Damage is not allowable.	
		i. Fuel bleed line insulation for damage.	See figure 1-3 for damage limits.	
		j. Fuel turbine cavity double diaphragm area for water (area between fuel turbine manifold torus "hat section" over expansion joint, between fuel turbine manifold and pump housing).	Water is not allowable.	
		k. Fuel turbine exhaust duct manifold cavity for foreign objects and water.	Water or foreign objects are not allowable.	
		l. The following external surfaces of engine for moisture:	Moisture is not allowable on external surfaces.	
		(1) Oxidizer inlet duct.		
		(2) Fuel inlet duct.		
		(3) Gimbal bearing/dome depression area on thrust chamber.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.11 (cont)		g. Fuel inlet duct for:		Insulation must not be removed for inspection.
		(1) Bellows convolution damage.	See figures 1-3 and 1-4 for damage limits.	
		(2) Missing roll pins.	Missing roll pins are not allowable.	
		(3) Distorted convolutions.	Minimum allowable space between convolutions on vacuum jacket bellows is 0.060 inch.	Engine must be within ±2 degrees of null position.
		h. Fuel high-pressure duct insulation for cracks and cuts.	Damage is not allowable.	
		i. Fuel bleed line insulation for damage.	See figure 1-3 for damage limits.	
		j. Fuel turbine cavity double diaphragm area for water (area between fuel turbine manifold torus "hat section" over expansion joint, between fuel turbine manifold and pump housing).	Water is not allowable.	
		k. Fuel turbine exhaust duct manifold cavity for foreign objects and water.	Water or foreign objects are not allowable.	
		l. The following external surfaces of engine for moisture:	Moisture is not allowable on external surfaces.	
		(1) Oxidizer inlet duct.		
		(2) Fuel inlet duct.		
		(3) Gimbal bearing/dome depression area on thrust chamber.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.11 (cont)		(4) Cavity between fuel manifold and thrust chamber.		
		(5) Cavity between turbine exhaust manifold and thrust chamber.		
		m. Enter inspection information in Engine Log Book.		
1.1.12	<u>ENGINE VISUAL INSPECTION DURING LAUNCH PREPARATION</u>	Visually inspect:		Visual inspection must be performed before removal of workstands.
		a. Exposed and accessible portions of engine for:		Component removal or system disassembly is not required.
		(1) Verification of removal of all protective covers and closures.	All engine protective covers and closures must be removed before tanking propellants.	
		(2) Verification of removal of the following test plates, plugs, and adapters used in leak and function testing:	Test plates, plugs, and adapters must be removed.	Engine connections affected by test equipment must be correctly reinstalled/reconnected.
		(a) Thrust chamber throat plug.		
		(b) Plate between heat exchanger and exhaust manifold.		
		(c) Plate between OTBV and exhaust duct.		
		(d) Plate on fuel turbine torque access; verify that plug has been reinstalled.		
		(e) Plate on OTBV closing control port.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12 (cont)		(f) Plate between OTBV and OTBV opening control line.		
		(g) Plate between purge control valve and valve inlet line.		
		(h) Plate between pneumatic accumulator and accumulator hose.		
		(i) Plate between fuel bleed valve control port and control line.		
		(j) Plate between oxidizer bleed valve control port and control line.		
		(k) Plate between STDV bleed port and bleed line.		
		(l) Plate between purge control valve vent port and vent line.		
		(m) Test plate on GG oxidizer purge line flange downstream of check valve.		
		(n) Test plug in oxidizer injector purge test port CN1; verify that proper plug has been reinstalled.		
		(o) Test plate on FUEL PUMP DRAIN customer connect.		
		(p) Test adapter on oxidizer turbine seal cavity drain line.		
		(q) Test adapter on fuel turbine seal cavity drain line.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12 (cont)		(r) Test adapter in fitting between fuel turbopump and fuel turbopump drain check valve; verify that plug has been reinstalled.		
		(s) Vent adapter in boss in MFV closing control line; verify that vent port relief valve has been reinstalled.		
		(t) Verification that oxidizer turbopump torque access cover plate has been reinstalled.		
		(3) Cleanness.	Dirt or foreign objects are not allowable on engine or component surfaces.	
		(4) Safetywiring.	Broken, loose, or damaged lockwire is not allowable.	
		b. Gimbal boot for tears, damaged convolutions, and security.	Damage is not allowable.	
		c. ASI for:		
		(1) Spark igniter cable ablative protective cover damage.	See figure 1-3 for damage limits.	
		(2) Fuel and oxidizer line damage.	Damage is not allowable.	
		(3) Clearance between fuel and oxidizer lines and main injector.	Minimum allowable clearance is 0.030 inch.	Instrumentation pickups attached to propellant lines are allowed to contact other surfaces.
		d. Thrust chamber insulation for damage.	Damage is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12 (cont)		e. ECA and primary and auxiliary FI packages for:		
		(1) Pressurization valve swivel nut security.	Looseness of swivel nut is not allowable.	Torque check is not required.
		(2) Protective cap installation.	Missing or uninstalled protective caps are not allowable.	
		(3) Bonding cable security at termination points.	Looseness at cable termination point is not allowable.	
		f. ECA and ECA support rod insulation for damage.	Damage is not allowable.	
		g. Start tank insulation cover for damage.	See figure 1-3 for damage limits.	
		h. STDV hose for chafed or damaged braid.	See figure 1-3 for damage limits.	
		i. Oxidizer high-pressure duct rod for installation.	Looseness of rod is not allowable.	
		j. Oxidizer inlet duct for:		
		(1) Bellows convolution damage (SIVB-stage engines only).	See figures 1-3 and 1-4 for damage limits.	
		(2) Proper installation of bipod retaining pins.	Each retaining pin must extend through and protrude at least 1/16 inch on each side of bipod pivot pin.	
		k. Oxidizer propellant system insulation for cracks, cuts, and gouges (SII-stage engines).	Damage is not allowable.	
		l. Heat exchanger antiflood check valve for proper safetywiring (S-II stage engines).	Broken or loose lockwire is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12 (cont)		m. Oxidizer turbine exhaust duct and manifold for:		
		(1) Dents.	Damage is not allowable.	
		(2) Convolution distortion.	Distortion is not allowable.	
		(3) Dented bellows.	Dents are not allowable.	
		(4) Accessory mounting pad closure installation (SII-stage center engine)	Missing or improperly installed closure is not allowable.	
		n. Fuel inlet duct bellows for convolution damage.	See figures 1-3 and 1-4 for damage limits.	Insulation must not be removed for inspection.
		o. Fuel inlet duct for:		Insulation must not be removed for inspection.
		(1) Missing roll pins.	Missing roll pins are not allowable.	
		(2) Proper installation of bipod retaining pin.	Each retaining pin must extend through and protrude at least 1/16 inch on each side of bipod pivot pin.	
		(3) Distorted convolutions.	Minimum allowable space between convolutions on vacuum jacket bellows is 0.060 inch.	Engine must be within ±2 degrees of null position.
		p. Fuel turbopump insulated volute cover for damage.	See figure 1-3 for damage limits.	
		q. Fuel high-pressure duct insulation for cracks and cuts.	Damage is not allowable.	
		r. Fuel bleed line insulation for damage.	See figure 1-3 for damage limits.	
		s. Fuel high-pressure duct rods for installation.	Looseness of rods is not allowable.	
		t. MFV insulation for damage (SII-stage center engine).	Damage is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12 (cont)		u. OTBV insulation for damage (SII-stage outboard engines).	Damage is not allowable.	
		v. Fuel turbine exhaust duct and manifold for:		
		(1) Dents.	Dents are not allowable.	
		(2) Convolution distortion.	Distortion is not allowable.	
		(3) Dented bellows.	Dents are not allowable.	
		(4) Verification of torque access cover installation.	Missing or improperly installed cover is not allowable.	
		w. GG for chafed or damaged braid on propellant inlet lines.	See figure 1-3 for damage limits.	
		x. Fast-shutdown valve insulation for damage (SII-stage outboard engines).	Damage is not allowable.	
		y. Vent port check valves for restrictions.	Impaired seating capability of valve is not allowable.	Tape or lockwire must not be over top of valve.
		z. Electrical and instrumentation armored harness for:		
		(1) Identification.	Missing or obliterated identification is not allowable.	
		(2) Exterior armor braid damage.	See figure 1-3 for damage limits.	
		(3) Clearance between harness and lines (tubing) less than 2-inch OD.	Minimum allowable clearance is 1/8-inch.	
		(4) Contact with components or lines that contain or flow hot-gas products.	Direct contact is not allowable except for normal connections (electrical connectors connected to components installed in system).	Indirect contact is acceptable, such as harness contact with a support attached to hot-gas component.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12 (cont)		(5) Contact with sharp edges.	Contact is not allowable with edges having radii that are less than 0.12 inch.	
		(6) Overmold damage.	See figure 1-3 for damage limits.	When determining extent of adhesion or bonded area, overmold must not be flexed, pried, or pulled away from armor braid or other surface on which it is positioned. Heat-shrinkable overmolds are not intended as moisture seals.
		aa. Electrical and instrumentation harness connectors for:		Torque relaxation of connectors is a normal occurrence; connectors must not be checked for torque relaxation and must not be retorqued.
		(1) Damaged rubber boots.	See figure 1-3 for damage limits.	
		(2) Identification.	Missing or obliterated identification is not allowable.	
		ab. Interface electrical and instrumentation connectors for identification.	Missing or obliterated identification is not allowable.	Torque relaxation of connectors is a normal occurrence; connectors must not be checked for torque relaxation and must not be retorqued.
		ac. Interconnecting pneumatic tubing for:		
		(1) Distorted lines.	Line distortion is not allowable.	
		(2) Leak-test pins missing at flanges.	Missing leak-test pins are not allowable.	
		ad. Instrumentation lines for bends at line weld joint to stub-out fitting.	Maximum allowable bend angle at stub-out weld is 10 degrees.	Line must not be straightened.

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12 (cont)		ae. Customer-connect fluid lines for:		
		(1) Chafed and damaged braid.	See figure 1-3 for damage limits.	
		(2) Clearance between lines and adjacent surfaces.	Minimum allowable clearance is 1/8 inch.	Contact is allowable between engine fluid interface lines from the engine support bracket to the customer connect interface. Contact is allowable between fuel bleed line and heat exchanger helium line from either side of engine-mounted fluid-line interface support bracket to first bend in heat exchanger helium line (SIVB stage).
		af. Lines of less than 2-inch OD for:		
		(1) Clearance between lines and adjacent surfaces.	Minimum allowable clearance is 1/8 inch.	Lines are allowed to contact thermal insulation (including electrical harness boot), oxidizer and fuel turbopump (if lines are installed as part of turbopump), and engine support bracket.
		(2) Clearance between stage static instrumentation line GG1a and main oxidizer valve housing.	Minimum allowable clearance is 0.060 inch.	
		(3) Clearance between fuel bleed line and start tank gaseous refill line.	Minimum allowable clearance is 0.030 inch.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12 (cont)		ae. Customer-connect fluid lines for:		
		(1) Chafed and damaged braid.	See figure 1-3 for damage limits.	
		(2) Clearance between lines and adjacent surfaces.	Minimum allowable clearance is 1/8 inch.	Contact is allowable between flexible sections of fluid interface lines located between support bracket and customer-connect fluid interface panel. Contact is allowable between fuel bleed line and heat exchanger helium line from either side of engine-mounted fluid-line interface support bracket to first bend in heat exchanger helium line (SIVB stage).
		af. Lines of less than 2-inch OD for:		
		(1) Clearance between lines and adjacent surfaces.	Minimum allowable clearance is 1/8 inch.	Lines are allowed to contact thermal insulation (including electrical harness boot), oxidizer and fuel turbopump (if lines are installed as part of turbopump), and engine support bracket.
		(2) Clearance between stage static instrumentation line GG1a and main oxidizer valve housing.	Minimum allowable clearance is 0.060 inch.	
		(3) Clearance between fuel bleed line and start tank gaseous refill line.	Minimum allowable clearance is 0.030 inch.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.12 (cont)		ag. Clamps on lines containing flexible sections.	Clamps are not allowable on flexible section of lines.	
		ah. Enter inspection information in Engine Log Book.		
1.1.13	<u>ENGINE LOG BOOK ORIFICE VERIFICATION</u>	Inspect engine variable orifices for agreement with Engine Log Book.	External identification (orifice tag) of each orifice installed in engine must agree with orifice identification recorded in Engine Log Book.	
1.1.14	<u>ENGINE LOG BOOK AUDIT</u>	Verify Engine Log Book entries for correctness using Engine and Stage Contractor records as a basis for determining engine status.	Entries must be complete and accurate.	
1.1.15	<u>ENGINE GIMBALING CLEARANCE CHECK</u>	a. Inspect engine for clearance between engine and stage or facility when engine is moved through maximum allowable gimbal envelope.	One inch minimum clearance is required between engine and stage or facility.	
		b. Enter gimbaling information in Engine Log Book.		
1.1.16	<u>HUMIDITY INDICATOR INSPECTION, ENGINE NOT IN STORAGE</u>			When the engine diffuser is installed the thrust chamber exit closure does not contain desiccant, therefore the exit closure humidity indicator inspection is not required.
		a. Inspect humidity indicators for evidence of excessive moisture at 7-day maximum intervals.	30 percent maximum humidity (color other than blue in 30 percent spot is not allowable).	When the humidity indicator 30 percent spot turns a color other than blue, replace desiccant and perform step b. (Refer to desiccant installation requirements outlined in section II.)
		b. Inspect humidity indicators for evidence of excessive moisture 24 hours after desiccant replacement.	30 percent maximum humidity (color other than blue in 30 percent spot is not allowable).	If 30 percent spot shows color other than blue, replace desiccant and repeat inspection after 24 hours. This inspection and desiccant replacement cycle may be repeated a maximum of five times before trouble analysis must be performed.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.17	<u>HUMIDITY INDICATOR INSPECTION, ENGINE STORED IN STAGE</u>	a. Inspect humidity indicators for evidence of excessive moisture at 30-day maximum intervals.	30 percent maximum humidity (color other than blue in 30 percent spot is not allowable).	When the humidity indicator 30 percent spot turns a color other than blue, replace desiccant and perform step b. (Refer to desiccant installation requirements outlined in section II.) When the stage/engine has been stored in accordance with MSFC-STD-496 or MSFC-STD-498 the 30-day interval inspections of the oxidizer and fuel inlet duct torsional bellows cover humidity indicators are not required.
		b. Inspect humidity indicators for evidence of excessive moisture 24 hours after desiccant replacement.	30 percent maximum humidity (color other than blue in 30 percent spot is not allowable).	If 30 percent spot shows color other than blue, replace desiccant and repeat inspection after 24 hours. This inspection and desiccant replacement cycle may be repeated a maximum of five times before trouble analysis must be performed.
		c. Enter inspection information in Engine Log Book.		
1.1.18	<u>HUMIDITY INDICATOR INSPECTION, UNINSTALLED ENGINE IN STORAGE</u>	Perform requirements of paragraph 1.1.18.1 or 1.1.18.2 and enter information in Engine Log Book at completion of inspection.		
1.1.18.1	<u>HUMIDITY INDICATOR INSPECTION, ENGINE STORED ON ENGINE HANDLER G4064</u>	a. Inspect engine cover humidity indicator for evidence of excessive moisture at 30-day maximum intervals.	30 percent maximum humidity (color other than blue in 30 percent spot is not allowable).	When the humidity indicator 30 percent spot turns a color other than blue, inspect engine closure humidity indicators as outlined in step b.
		b. If engine cover humidity indicator shows evidence of excessive moisture, remove cover and inspect humidity indicators on the following engine closures for evidence of excessive moisture: (1) Oxidizer pump inlet. (2) Fuel pump inlet. (3) Thrust chamber exit. (4) Oxidizer inlet duct torsional bellows. (5) Fuel inlet duct torsional bellows.	30 percent maximum humidity (color other than blue in 30 percent spot is not allowable).	When the humidity indicator 30 percent spot turns a color other than blue, replace desiccant and perform step c. (Refer to desiccant installation requirements outlined in section II.)

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.1.18.1 (cont)		c. Inspect humidity indicators for evidence of excessive moisture 24 hours after desiccant replacement.	30 percent maximum humidity (color other than blue in 30 percent spot is not allowable).	If 30 percent spot shows color other than blue, replace desiccant and repeat inspection after 24 hours. This inspection and desiccant replacement cycle may be repeated a maximum of five times before trouble analysis must be performed.
		d. If engine cover was removed, replace engine handler desiccant, reinstall engine cover and perform step c.		Refer to desiccant installation requirements outlined in section II.
1.1.18.2	<u>HUMIDITY INDICATOR INSPECTION, ENGINE STORED IN VERTICAL POSITION</u>	a. Inspect humidity indicators on the following engine closures for evidence of excessive moisture at 30-day maximum intervals: (1) Oxidizer pump inlet. (2) Fuel pump inlet. (3) Thrust chamber exit. (4) Oxidizer inlet duct torsional bellows. (5) Fuel inlet duct torsional bellows.	30 percent maximum humidity (color other than blue in 30 percent spot is not allowable).	When the humidity indicator 30 percent spot turns a color other than blue, replace desiccant and perform step b. (Refer to desiccant installation requirements outlined in section II.)
		b. Inspect humidity indicators for evidence of excessive moisture 24 hours after desiccant replacement.	30 percent maximum humidity (color other than blue in 30 percent spot is not allowable).	If 30 percent spot shows color other than blue, replace desiccant and repeat inspection after 24 hours. This inspection and desiccant replacement cycle may be repeated a maximum of five times before trouble analysis must be performed.
1.1.19	<u>STRESS CORROSION INSPECTION</u>	Inspect primary and auxiliary flight instrumentation package transducers not incorporating <u>MD343</u> compression plates for stress corrosion cracks in mounting flange adjacent to sensing line. Inspect visible areas of mainstage OK pressure switches base (CAL) for stress corrosion cracks.	Crack-like defects not exceeding 0.1 inch maximum.	Perform inspection of all accessible stress corrosion sensitive components within 60 days prior to placement of engine/stage into storage. Perform inspection within 60 days after removal of engine/stage from storage. Subsequent inspections must be performed within 90-day intervals with a final inspection within 30 days prior to launch. Use illumination, mirrors, and magnification up to 10X where necessary to obtain better definition or to clarify suspect areas.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2	ELECTRICAL TESTS			
1.2.1	FLIGHT INSTRUMENTATION SYSTEM TEST FOR UNINSTALLED ENGINES	Calibration-test FI parameters.		Calibration-test requirements are based upon use of Flight Instrumentation Checkout Console G1035.
		a. Perform the following steps to test pressure transducers.		
		(1) Measure and record initial (ambient), 20-percent, and 80-percent output voltage of each pressure transducer.	Test voltage values must be within limits of figure 1-6.	
		(2) Refer to Engine Log Book and calculate difference in voltage (ΔE) between initial (ambient) and 20-percent-calibrate readouts recorded during engine final acceptance checkout for oxidizer pump primary seal cavity parameter (P06) and oxidizer turbine outlet parameter (TG4). For all other pressure parameters, calculate difference in voltage (ΔE) between 20-percent-calibrate and 80-percent-calibrate readouts.		If transducer has been replaced in the field, use new values recorded in Engine Log Book during first calibration test after transducer replacement.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.1 (cont)		(3) For parameter P06 and parameter TG4, calculate difference in voltage (ΔE) between initial readout and 20-percent-calibrate readout recorded in substep 1. For all other pressure parameters, calculate difference in voltage (ΔE) between 20-percent-calibrate readout and 80-percent-calibrate readout recorded in substep 1.		
		b. Record voltage values in Engine Log Book.		
		c. Measure output test voltages of each temperature transducer at ambient temperature and with electrically simulated calibration inputs applied. (On dual-element transducer, measure both A- and B-sensor outputs.)	Test voltage must be within limits of figure 1-7.	If low-calibrate and/or high-calibrate readings are not within limits, console signal conditioner panel amplifiers must be adjusted and test repeated.
		d. Measure output test voltages of the following valve position potentiometers:	Voltage Limits (vdc)	
		(1) MFV.	0.500 ±0.400	
		(2) MOV.	0.500 ±0.400	
		(3) GG control valve.	0.500 ±0.400	
		(4) STDV.	0.500 ±0.400	
		(5) OTBV.	4.500 ±0.400	
		(6) PU valve.	0.250 (+0.250, -0.240)	
		(7) MRCV (MD371 change)	0.490 ±0.400	
		(8) MRCV (MD366 change)	1.730 (+0.250, -0.250)	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.1 (cont)		e. Measure output test voltages of the following turbopump speed and propellant flowrate transducers:	Voltage Limits (vdc)	
		(1) Fuel turbopump speed (above cutoff).	4.680 ±0.250	
		(2) Fuel turbopump speed (below cutoff).	4.420 ±0.250	
		(3) Oxidizer turbopump speed (above cutoff).	5.000 ±0.250	
		(4) Oxidizer turbopump speed (below cutoff).	4.240 ±0.250	
		(5) Main fuel flowrate.	3.330 ±0.250	
		(6) Main oxidizer flowrate.	3.330 ±0.250	
1.2.2	PROPELLANT UTILIZATION VALVE TEST FOR UNINSTALLED ENGINES	Verify valve operation by measuring voltage output of position indicator potentiometer for the following valve positions (indicated as percent of valve opening on electrical checkout console meter):	Potentiometer Voltage Limits (vdc)	Test requirements are based upon use of Data Recorder Console G3121, Flight Instrumentation Checkout Console G1035, and Electrical Checkout Console G1037. PU valve controller panel power must be on only when PU valve is being tested.
		a. Valve fully open, 100 (+0, -10) percent.	4.750 ±0.250	
		b. Valve fully closed, 0 (+10, -0) percent.	0.010 to 0.500	If valve oscillations are observed on recorder trace during test, PU valve position controller panel amplifier in electrical checkout console must be adjusted.
1.2.2A	MIXTURE RATIO CONTROL VALVE TEST FOR UNINSTALLED ENGINES (ENGINES INCORPORATING MD366 OR MD371 CHANGE)	a. Verify MRCV operation by measuring voltage output of position indicator potentiometer for valve open and close positions as follows:		Test requirements are based upon use of Data Recorder Console G3121, Flight Instrumentation Checkout Console G1035, Electrical Checkout Console G1037, and Pneumatic Checkout Console G3106.
		(1) Pressurize engine helium tank to 1,400-1,600 psig.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.2A (cont)		(2) Readout MRCV position transducer.	Voltage must be 0.49 ±40 volt on engines incorporating MD371 change or 1.73 ±25 volts on engines incorporating MD366 change.	
		(3) Energize MRCV control solenoid, then energize engine helium control valve.	MRCV must move to open position and potentiometer output voltage change must be between 1.3 and 1.8 vdc on engines incorporating MD371 change, or between 0.6 and 1.0 vdc on engines incorporating MD366 change.	The engine mainstage control valve may be energized to prevent excessive loss of helium through the engine purges. Allow minimum of 2 seconds between substeps 3, 4, and 5 to obtain valid readings.
		(4) Deenergize MRCV control solenoid.	MRCV must move to close position and potentiometer output voltage change must be between 1.3 and 1.8 vdc on engines incorporating MD371 change, or between 0.6 and 1.0 vdc on engines incorporating MD366 change.	
		(5) Deenergize helium control valve.		
		(6) Determine MRCV operating times.	MRCV operating times must be within limits of figure 1-11.	
1.2.3	<u>ENGINE ELECTRICAL SAFETY CIRCUIT TESTS FOR UNINSTALLED ENGINES</u>			This test must be performed before mainstage OK pressure switch and engine sequence tests. A minimum delay of 5 minutes is required between each test in this paragraph.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.3 (cont)		a. Test for delay in engine sequence when fuel injection temperature OK signal (engines incorporating ECA 502670-211) or main-stage enable signal (engines incorporating MD204 change or not incorporating ECA 502670-211) is not obtained.	Engine sequence must stop following runout of start tank discharge delay timer, preventing the initiation of the following events: (1) STDV control valve energized (2) Ignition-phase timer energized	
		b. Test for cutoff in engine sequence when start tank depressurized signal not obtained (engines incorporating ECA 502670-211).	Engine sequence cutoff must be obtained following indication of STDV control valve energized.	
		c. Test for cutoff in engine sequence when ignition-detected signal is not obtained after engine start.	Engine sequence cutoff must be obtained following indication of STDV control valve energized.	
		d. Test for no cutoff in engine sequence when either No. 1 or No. 2 (but not both) mainstage OK pressure switch signal is not obtained after engine start.	Engine sequence must not be cut off by absence of signal from one of the two pressure switches.	
		e. Test for cutoff in engine sequence when neither of the mainstage OK pressure switch signals is obtained after engine start.	Engine sequence cutoff must be obtained following runout of sparks deenergized timer.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.4	<u>FLIGHT INSTRUMENTATION SYSTEM TEST</u>	a. Perform the following steps to test pressure transducers:		Transducers not connected to stage instrumentation system do not require testing. Instrumentation system voltages must be within limits listed in section II. Transducer output voltages are referenced to electrical interface customer connect.
		(1) Measure and record initial (ambient), 20-percent, and 80-percent output voltage of each pressure transducer.	Test voltage values must be within limits of figure 1-6.	When an initial (ambient) readout value is less than the low-end capability of the measuring equipment, ignore initial readout and use data from 20 and 80 percent readouts for transducer acceptance.
		(2) Refer to Engine Log Book and calculate difference in voltage (ΔE) between initial (ambient) and 20-percent-calibrate readouts recorded during engine final acceptance checkout for oxidizer pump primary seal cavity parameter (P06) and oxidizer turbine outlet parameter (TG4). For all other pressure parameters, calculate difference in voltage (ΔE) between 20-percent-calibrate and 80-percent-calibrate readouts.		If transducer has been replaced in the field, use new values recorded in Engine Log Book during first calibration test after transducer replacement.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.4 (cont)		(3) For parameter P06 and parameter TG4, calculate difference in voltage (ΔE) between initial readout and 20-percent-calibrate readout recorded in substep 1. For all other pressure parameters, calculate difference in voltage (ΔE) between 20-percent-calibrate readout and 80-percent-calibrate readout recorded in substep 1.	Voltage difference (ΔE) value must be within ±0.100 vdc (±2 percent of 5-vdc full scale) of corresponding ΔE calculated from Engine Log Book data (substep 2).	
		b. Record voltage values in Engine Log Book.		
		c. Verify resistance of each of the following temperature transducers in conjunction with stage signal conditioning equipment during ambient calibration: (On dual-element transducers, both A- and B-sensors must be measured.)	Resistance values must be within the following limits:	Temperature transducers must be between 38° F and 110° F. Resistance limits are referenced to customer-connect interface. Currents allowed to flow through resistance elements must be within the following limits:
			<u>Resistance Limits (ohms)</u>	<u>Maximum Test Current (amps)</u>
		(1) Fuel injection CFT2 (SIVB stage engines only).	1,370 ±100	0.0047
		(2) Thrust chamber jacket No. 1 CS1.	1,370 ±100	0.0047
		(3) Thrust chamber jacket No. 2 CS1a.	1,370 ±100	0.0047
		(4) Oxidizer turbine outlet TGT4 (on engines not incorporating <u>MD263</u> or <u>MD355</u> change).	55 ±5	0.0015
		(5) Oxidizer turbine inlet TGT3 (on engines not incorporating <u>MD263</u> change).	55 ±5	0.0015

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.4 (cont)			Resistance Limits (ohms)	Maximum Test Current (amps)
		(6) Fuel turbine inlet TGT1 (on engines not incorporating MD263 change).	55 ±5	0.0015
		(7) Start tank gas TFT1 (A- and B-sensors).	1,370 ±100	0.00083
		(8) Helium tank gas NNT1.	1,370 ±100	0.00083
		(9) ECA No. 1.	218 ±17	0.0015
		(10) ECA No. 2.	218 ±17	0.0015
		(11) Auxiliary FI package.	218 ±17	0.0015
		(12) Primary FI package.	218 ±17	0.0015
		(13) Heat exchanger oxidizer outlet HOT2 (A- and B-sensors) on SII-stage engines only.	465 ±33	0.0009
		(14) Oxidizer turbopump bearing coolant POT4.	1,370 ±100	0.0007
		(15) Fuel turbopump bearing PST1 (on engines not incorporating MD172 or MD290 change).	1,370 ±100	0.0047
		(16) MOV closing control line (SII-stage engines incorporating MD290 change).	109 ±9	0.0021
		(17) MOV housing (SII-stage engines incorporating MD290 change).	109 ±9	0.0021
		d. Test turbopump speed and propellant flowrate transducers secondary and/or primary coil for continuity in conjunction with stage signal conditioning equipment.	Continuity must exist through secondary and/or primary coil.	Engine Contractor recommended checkout criteria are listed in figure 1-8.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.5	IGNITION DETECTOR PROBE RESISTANCE TEST	Measure resistance between the following points on ignition detector probe electrical receptacle J19:		This test must be performed within 30 days before stage static test and as near test date as practical. Nominal resistance limit values of 0.1, 100, and 200 ohms must be measured with an instrument accurate to one percent or better.
			Resistance Limits (ohms)	Test Voltage Limits VDC Maximum
		a. Pin A to pin B.	100 ±2.5	5
		b. Pin B to pin C.	100 ±2.5	5
		c. Pin A to pin C.	200 ±5.0	5
		d. Pin B to pin D.	Greater than 100,000	
		e. Pin B to case.	Greater than 100,000	
		f. Pin D to case.	Greater than 100,000	
		g. Pin F to case.	Less than 0.1	
		h. Pin D to pin E.	Less than 0.1	
1.2.6	PROPELLANT UTILIZATION VALVE TEST FOR STAGE STATIC TEST (ENGINES NOT INCORPORATING MD366 OR MD371 CHANGE)	Before engine static firing, verify valve operation by measuring voltage output of position indicator potentiometer (with 5.00 ±0.50 vdc input applied to potentiometer) and calculating voltage ratio for the following valve positions:	Voltage Ratio Limits	PU valve control power must be within limits listed in section II. Voltage ratio is quotient of potentiometer output voltage divided by potentiometer input voltage.
		a. Valve fully closed.	0.002 to 0.1	
		b. Valve fully open.	0.9 to 1.0	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.6A	MIXTURE RATIO CONTROL VALVE TEST FOR STAGE STATIC TEST, CDDT, AND LAUNCH COUNT-DOWN (ENGINES INCORPORATING MD366 OR MD371 CHANGE)	a. Verify MRCV operation at cryogenic temperatures by measuring voltage output of position indicator poten-tiometer for high EMR and low EMR positions as follows:		At KSC, this test must be performed before helium supply system pressure-decay test of paragraph 1.3.48A. This test verifies, within limitations of measuring system, operation of MRCV. Engine helium tank must be pressurized to 2,800-3,450 psig. Engine control must be in components test mode and liquid oxygen must be in MRCV for a minimum of 1/2 hour. CAUTION When performing this test do not energize en-gine ignition phase or mainstage control valves. Allow minimum of 2 seconds between substeps 2, 3, and 4 to obtain valid readings. Time between substeps 2, 3, and 4 should be held as close to minimum as possible to prevent excess helium loss through engine purges.
		(1) Readout valve position transducer.		
		(2) Energize low EMR command; then energize engine helium control valve.	MRCV must move to low EMR and potentiometer output voltage change must be between 1.3 and 1.8 vdc on engines incorporating MD371 change, or between 0.6 and 1.0 vdc on engines incor-porating MD366 change. Time from helium control valve energize command (high EMR) signal to MRCV low EMR posi-tion must be a maximum of 1.0 second.	
		(3) Deenergize low EMR command.	MRCV must move to high EMR and potentiometer output voltage change must be between 1.3 and 1.8 vdc on engines incorporating MD371 change, or between 0.6 and 1.0 vdc on engines incor-porating MD366 change. Time from low EMR command de-energize signal to MRCV high EMR position must be a maximum of 1.2 seconds.	
		(4) Deenergize helium control valve.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.7	<u>PROPELLANT UTILIZATION VALVE TEST DURING STAGE STATIC-TEST SECURING AND CHECKOUT AT VAB (ENGINES NOT INCORPORATING MD366 OR MD371 CHANGE)</u>	Verify valve operation by measuring voltage output of position indicator potentiometer (with 5.00 ±0.50 vdc input applied to potentiometer) and calculating voltage ratio for the following valve positions:	<u>Voltage Ratio Limits</u>	Voltage ratio is quotient of potentiometer output voltage divided by potentiometer input voltage.
		a. Valve fully closed.	0.002 to 0.1	
		b. Valve fully open.	0.9 to 1.0	
1.2.8	<u>PROPELLANT UTILIZATION VALVE TEST DURING COUNTDOWN DEMONSTRATION TEST AND FOR LAUNCH PREPARATION (ENGINES NOT INCORPORATING MD366 OR MD371 CHANGE)</u>	Verify PU valve response after propellant loading.	Valve must respond to input command signals.	
1.2.9	<u>IGNITION-PHASE CONTROL VALVE, MAINSTAGE CONTROL VALVE, START TANK DISCHARGE VALVE CONTROL VALVE, HELIUM CONTROL VALVE, HELIUM TANK EMERGENCY VENT VALVE, START TANK EMERGENCY VENT VALVE, AND MIXTURE RATIO CONTROL VALVE RESISTANCE TEST</u>			At KSC, this test must be performed within 120 days before launch. Power must not be applied to solenoid coils within 4 hours before making resistance test.
		a. Measure resistance between pins A and B of the following control valve receptacles: (1) J14 (ignition-phase control valve). (2) J15 (mainstage control valve). (3) J18 (STDV control valve). (4) J13 (helium control valve). (5) J17 (helium tank emergency vent valve).	Resistance must be within temperature-compensated limits shown in figures 1-8A, 1-8B, and 1-8C.	The following equipment is required for this test: 1. Wheatstone bridge or digital ohmmeter (accuracy within ±0.1 ohm) 2. Insulation resistance tester, 500 vdc (accuracy within ±10% and current limited to 10 ma maximum at 500 vdc) 3. Strap-on thermometer (accuracy within ±2.0°F)

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.9 (cont)		(6) J55 (start tank emergency vent valve).		
		(7) J36A (MRCV) (engines incorporating MD366 or MD371 change).		
		b. Measure insulation resistance (with 500 vdc applied) between the following points of control valve receptacles J14, J15, J18, J13, and J17:	Minimum allowable insulation resistance is 50 megohms.	
		(1) Pins A and B (together) to ground.		
		(2) Pin C to ground.		
		(3) Pins A and B (together) to pin C.		
		c. Measure insulation resistance (with 500 vdc applied) between control valve receptacle J55, pins A and B (together), and ground, and on engines incorporating MD366 or MD371 change, between control valve receptacle J36A, pins A and B (together), and ground.	Minimum allowable insulation resistance is 50 megohms.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.10	ENGINE ELECTRICAL SYSTEM RESISTANCE-TO-GROUND TEST	Measure resistance between all pins shorted together of interface electrical connector P51 and ground, with interface connectors P51 and P54 disconnected.	Resistance must be greater than 5 megohms.	This test must be done at KSC.
1.2.11	ENGINE ELECTRICAL SAFETY CIRCUIT TESTS			A minimum delay of 5 minutes is required between each test in this paragraph if ignition power is turned on. Ignition power is not required during performance of electrical safety circuits test. On engines incorporating MD338 change, any time an ignition-complete indication is obtained, ignition detection simulation circuit must not be energized.
		a. Test for delay in engine sequence when mainstage enable signal is not obtained on SIVB-stage engines.	Engine sequence must stop following runout of start tank discharge valve delay timer, preventing the start of the following events: (1) STDV control valve energized. (2) Ignition-phase timer energized.	This test is not required on SII-stage engines.
		b. Test for cutoff in engine sequence when ignition-detected signal is not obtained after engine start (on engines not incorporating MD338 change).	Engine sequence cutoff must be obtained following indication of STDV control valve energized.	This test is not required on engines incorporating MD338 change.
		c. Test for cutoff in engine sequence when neither of the mainstage OK pressure switch signals is obtained.	Engine sequence cutoff must be obtained following runout of sparks deenergized timer.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.12	SPARK IGNITER TEST	Visually verify operation of each ASI spark igniter, and audibly verify operation of each GG spark igniter.	Indication of igniter operation must be obtained.	Spark igniter duty cycles are 10 seconds on and 5 minutes off, or 5 seconds on and 3 minutes off. These time intervals must not be exceeded during testing. Audible interference from ASI spark igniter operation must be muffled using an ASI chamber blocking device in order to enable audible verification of GG spark igniter operation.
1.2.13 through 1.2.15 (Deleted)				
1.2.16	ENGINE CUTOFF COMMAND AFTER LAUNCH COUNT-DOWN ABORT	Energize engine cutoff command circuit.	Engine cutoff signal must be obtained.	This requirement must be done before performing any post-abort engine operations.
1.2.17	ENGINE CUTOFF RESET FOR RESCHEDULED LAUNCH COUNTDOWN	Energize engine cutoff reset circuit.	Engine cutoff reset signal must be obtained.	

Pages 1-73 and 1-74 deleted.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.14	GAS GENERATOR HIGH-LOW TEMPERATURE CUTOFF PANEL PREOPERATION TEST	Test GG high-low temperature cutoff panel and engine interconnection by performing engine control system sequential operation (sequence test) or sequence simulation (to mainstage phase) with cutoff panel in operating mode and connected to GG overtemperature transducer.	Engine cutoff must be obtained 0.5 ±0.05 second after mainstage control signal.	If a component or entire panel is replaced, panel must be calibration tested and timer, limit switch, and amplifier settings adjusted to provide high and low temperature and time cutoff limits for engine operating requirements in section II. Preoperation test verifies GG undertemperature cutoff. Temperature monitored at GG high-low temperature cutoff panel may be compared with fuel turbine inlet temperature monitored on flight instrumentation; temperature indications should be about the same.
1.2.15	SPARK MONITOR/ OVERSPEED CUTOFF PANEL PREOPERATION TEST	a. Spark Monitor Preoperation Test. Actuate engine spark control individually with engine control system in component test mode.	Spark OK signals must be obtained.	Spark system duty cycle requirements in section II must be complied with.
		b. Overspeed Cutoff Preparation Test. Test cutoff operation with signal generator test input of 0.75 ±0.25 volt peak applied to connect points corresponding to connector J4, pins E and F for fuel turbopump speed and pins A and B for oxidizer turbopump speed:		Fuel turbopump overspeed cutoff limits (rpm) for engine operating requirements are in section II.
		(1) Signal generator test input frequency set below cutoff frequency range.	Cutoff signal indication must not be obtained.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.2.15 (cont)		(2) Signal generator test input frequency increased until cutoff indication obtained:	Cutoff signal must be obtained within the following frequency limits:	If cutoff signal is not within frequency limits, panel overspeed cutoff frequency may be adjusted and test repeated.
			Cutoff Frequency (Hz)	
		(a) Fuel turbopump speed (on engines J-2025 to J-2059).	5,680 ±50	
		(b) Fuel turbopump speed (on engines J-2060 and subsequent).	5,800 ±50	
		(c) Oxidizer turbopump speed (on all engines).	1,900 ±20	Oxidizer turbopump overspeed cutoff is not mandatory for engine static-firing tests.
		c. <u>Overspeed Cutoff Panel Resistance Test.</u> Measure resistance between facility ground and each connect point corresponding to a connector J4 pin (pins A, B, E, and F).	Resistance must be greater than 100,000 ohms.	Cutoff signals must be reset.
1.2.16	<u>ENGINE CUTOFF COMMAND AFTER STAGE STATIC TEST ABORT OR LAUNCH COUNTDOWN ABORT</u>	Energize engine cutoff command circuit.	Engine cutoff signal must be obtained.	This requirement must be done before performing any post-abort engine operations.
1.2.17	<u>ENGINE CUTOFF RESET FOR RESCHEDULED STAGE STATIC TEST OR LAUNCH COUNTDOWN</u>	Energize engine cutoff reset circuit.	Engine cutoff reset signal must be obtained.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3	LEAK AND FUNCTION TESTS			
1.3.1	ELECTRICAL CONTROL ASSEMBLY PACKAGE AND PRIMARY AND AUXILIARY FLIGHT INSTRUMENTATION PACKAGE PRESSURE MEASUREMENT			This test must be performed before engine storage, within 14 days after removal from storage controlled environment, and at KSC within 6 months before launch.
		a. Measure pressure in ECA or FI package, and determine amount of time in months since last pressurization or repressurization of package as recorded in Engine Log Book.	Measured pressure corrected to 70° F must be within acceptable limits of figure 1-8D.	Measurement requirements are based on use of spark igniter cable pressurization tool-kit 9025425-21. Temperature must be measured using a strap-on temperature measuring device connected to ECA or FI package face plate.
		b. Leak-test package pressurizing valve core by opening metal-to-metal seat and monitoring pressure gage for 5-6 minutes.	Maximum allowable pressure increase on gage is 0.3 psi (equivalent to 5×10^{-4} cc/sec).	
		c. Leak-test package pressurizing valve metal-to-metal seat by closing metal-to-metal seat, opening valve core, and monitoring pressure gage for 5-6 minutes.	Leakage is not allowable.	
		d. Inspect package pressurizing valve cap for evidence of damage to cap seal.	Damage is not allowable.	
		e. Record pressure monitoring information in Engine Log Book.		
1.3.2	SPARK IGNITER CABLE PRESSURE MEASUREMENT			This test must be performed at 12-month (maximum) intervals with at least one pressure check at KSC within 6 months before launch. The 12-month interval tests are not required when engine/stage is stored in accordance with MSFC-STD-496 or MSFC-STD-498. This test must be performed before engine storage and within 14 days after removal from storage controlled environment.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.2 (cont)		a. Measure pressure in ASI and GG SIC.	Pressure indicated on gage must be less than 30 psig.	Measurement requirements are based on use of spark igniter cable pressurization toolkit 9025425-21. If pressure exceeds limit, step b is required; otherwise; proceed to step d.
		b. Obtain and analyze gas sample from overpressurized SIC.	Pressurizing gas in SIC must contain less than one percent hydrogen.	If hydrogen content exceeds limit, step c is required.
		c. Obtain and analyze gas sample from ECA to which cable is connected.	Pressurizing gas in ECA must contain less than one percent hydrogen.	
		d. Calculate temperature-corrected pressure value, and determine amount of time in months since last pressurization or repressurization of SIC as recorded in Engine Log Book.	Measured pressure, corrected to 70° F, must be within acceptable limits of figure 1-8E.	Temperature must be measured using a strap-on temperature measuring device connected to ECA face plate.
		e. Leak-test pressurizing valve core by opening metal-to-metal seat and monitoring pressure gage for 5-6 minutes.	Maximum allowable pressure increase on gage is 0.3 psi (equivalent to 5×10^{-4} cc/sec).	
		f. Leak-test pressurizing valve metal-to-metal seat by closing metal-to-metal seat, opening valve core, and monitoring pressure gage for 5-6 minutes.	Leakage is not allowable.	
		g. Inspect SIC pressurizing valve cap for evidence of damage to cap seal.	Damage is not allowable.	
		h. Record pressure monitoring information in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.3	START SYSTEM TEST FOR UNINSTALLED ENGINES	a. Flange Joint, In-Place Tube Weld, and Line Braid Leak Tests. Pressurize start system to 500 ±10 psig.	Leakage is not allowable.	
		b. Start Tank Vent Valve Control Line Leak and Function Test. Pressurize control line to 250 psig maximum.	Leakage is not allowable. Start tank pressure must vent.	
1.3.4	START SYSTEM TEST DURING ENGINE POST-MANUFACTURING CHECKOUT	a. START TANK INITIAL FILL Customer-Connect Leak Test. Pressure start system to 500 ±20 psig.	Leakage is not allowable.	
		b. START TANK VENT VALVE CONTROL Customer-Connect Leak and Function Test. Pressurize control line to 585 psia maximum.	Leakage is not allowable. Start tank pressure must vent.	
1.3.5	START SYSTEM TEST FOR ENGINE CHECK-OUT AT MTF, SAC/MDAC, AND KSC	a. Flange Joint, In-Place Tube Weld, and Line Braid Leak Tests. Pressurize start system to 500 ±20 psig.	Leakage is not allowable.	Successful completion of start tank mass-loss test (restart engines) or the start tank pressure decay test (nonrestart engines) waives requirement to leak test start system at KSC. Except separable joints in the start tank initial fill line must be leak tested. Leakage measurements must be recorded during this test for entry in Engine Log Book.
		b. Seat Leakage Measurements. Measure the following seat leakages with start system pressurized to 500 ±20 psig:		Seat leakage measurements are not required in order to meet Engine Contractor minimum requirements.
		(1) Start tank vent-and-relief valve (measured at drain line exit).	Maximum allowable leakage is 2 scim.	This test is applicable to restart-mission engines only.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.5 (cont)		(2) STDV (measured at STDV drain line port on engines not incorporating MD234 change or at fuel turbine drain line exit on engines incorporating MD234 change).	Maximum allowable leakage is 5 scim.	Exhaust system test plates are required for this test.
		c. Check Valve Reverse-Leakage Measurements. Measure the following check valve reverse leakages with start system pressurized to 500 ±20 psig.		Check valve reverse-leakage measurements are not required in order to meet Engine Contractor minimum requirements. This test is applicable to restart-mission engines only. Thrust chamber throat plug is required for this test. Stage fuel tank pressurization system must be isolated from engine.
		(1) Start tank support-and-fill valve initial fill check valve (measured at initial fill line).	Maximum allowable leakage is 2 scim.	
		(2) Start tank gaseous and liquid refill check valves (combined leakages measured at throat plug test port).	Maximum allowable leakage is 5 scim.	If leakage exceeds limit, substeps 3 and 4 are required.
		(3) Start tank liquid refill check valve reverse leakage (measured at refill line flange after disconnection from ASI lower fuel line).	Maximum allowable leakage is 5 scim.	
		(4) Subtract leakage measured in substep 3 from leakage measured in substep 2 to determine start tank support-and-fill gaseous refill check valve reverse leakage.	Maximum allowable leakage is 5 scim.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.5 (cont)		d. Start Tank Vent Valve Control Line Leak and Function Test. Pressurize control line to 585 psia maximum.	Leakage is not allowable. Start tank pressure must vent.	Start tank vent valve control line leak test is not required at KSC.
		e. Record leakage measurements in Engine Log Book.		
1.3.6	START TANK EMERGENCY VENT VALVE TEST	Actuate emergency vent valve with start system pressurized to 100-500 psig.	Start tank pressure must vent.	The start tank emergency vent valve must be function tested at launch pad before cryogenic loading for countdown demonstration test. On restart mission engines, if start tank emergency vent valve is actuated after final scheduled start tank mass-loss test, mass-loss test must be repeated before launch. On nonrestart mission engines, if start tank emergency vent valve is actuated after final scheduled pressure-decay test, pressure-decay test must be repeated before launch or start tank pressure must be monitored during launch countdown (following final filling of start tank and after start tank ground fill line is vented), and pressure, if initially below 1,250 psia, must increase or, if pressure increases to above 1,250 psia, pressure must not subsequently decrease.
1.3.7	START TANK MASS-LOSS TEST FOR RESTART-MISSION ENGINES	a. Pressurize start tank initially to 500 ±20 psig and determine mass-loss rate.	Maximum allowable mass-loss rate is 0.0066 pound per hour.	If start tank emergency vent valve is actuated after final scheduled mass-loss test, mass-loss test must be repeated before launch.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.8 (cont)				If pressure-decay rate exceeds limit, testing must be continued until rate is acceptable or until 3 hours have elapsed from start of initial test.
1.3.9	<u>START TANK DISCHARGE VALVE PISTON AND PISTON LIP SEAL LEAK TEST (ENGINES NOT INCORPORATING MD275 CHANGE) AT MTF AND SAC/MDAC</u>	a. Pressurize helium tank to 225-250 psig with helium and ignition-phase control valves energized.		Mainstage control valve may be energized to conserve helium during test.
		b. Measure STDV piston closing lip seal leakage at STDV piston seal vent port.	Maximum allowable leakage is 40 scim.	
		c. Measure STDV piston opening lip seal leakage at STDV piston seal vent port with STDV control valve energized.	Maximum allowable leakage is 40 scim.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.9 (cont)		d. Measure leakage at STDV control valve vent port with STDV control valve deenergized.		If any leakage is measured in step d, steps e and f are required.
		e. Measure STDV leakage (indicating cracked piston) at STDV opening control port with STDV control valve deenergized.	Leakage is not allowable.	
		f. Subtract leakage measured in step e from leakage measured in step d to determine STDV control valve deenergized seat leakage.	Maximum allowable leakage is 15 scim.	
		g. Record leakage measurements in Engine Log Book.		
1.3.10	<u>START TANK DISCHARGE VALVE PISTON AND PISTON LIP SEAL LEAK TEST (ENGINES NOT INCORPORATING MD275 CHANGE) AT KSC</u>	a. Pressurize helium tank to 600-1,600 psig with helium and ignition-phase control valve energized.		Mainstage control valve may be energized to conserve helium during test.
		b. Measure STDV piston closing lip seal leakage at STDV piston seal vent port.	Maximum allowable leakage is 40 scim.	
		c. Measure STDV piston opening lip seal leakage at STDV piston seal vent port with STDV control valve energized.	Maximum allowable leakage is 40 scim.	
		d. Measure leakage at STDV control valve vent port with STDV control valve deenergized.		If any leakage is measured in step d, steps e and f are required.
		e. Measure STDV leakage (indicating cracked piston) at STDV opening control port with STDV control valve deenergized.	Leakage is not allowable.	
		f. Subtract leakage measured in step e from leakage measured in step d to determine STDV control valve deenergized seat leakage.	Maximum allowable leakage is 15 scim.	
		g. Record leakage measurements in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.11	START TANK DISCHARGE VALVE PISTON LIP SEAL LEAK TEST AT MTF AND SAC/MDAC ON ENGINES WITH START TANK DISCHARGE VALVE 304386 (MD275 CHANGE.	a. Pressurize helium tank to 225-250 psig with helium control and ignition-phase control valves energized.		Mainstage control valve may be energized to conserve helium during test.
		b. Measure leakage at STDV control valve vent port with STDV control valve deenergized.	Maximum allowable leakage is 15 scim.	If leakage exceeds limit, steps d and e are required.
		c. Measure leakage at STDV control valve vent port with STDV control valve energized.	Maximum allowable leakage is 15 scim.	If leakage exceeds limit, steps f and g are required.
		d. Measure leakage at STDV control valve vent port with a blocking test plate installed between STDV and opening control line restrictor check valve, and with STDV control valve deenergized.	Maximum allowable leakage is 15 scim.	
		e. Subtract leakage measured in step d from leakage in step b to determine STDV closing piston lip seal leakage.	Maximum allowable leakage is 100 scim.	
		f. Measure leakage at STDV control valve vent port with a blocking test plate installed between STDV and opening control line restrictor check valve, and with STDV control valve energized.	Maximum allowable leakage is 15 scim.	
		g. Subtract leakage measured in step f from leakage measured in step c to determine STDV opening piston lip seal leakage.	Maximum allowable leakage is 100 scim.	
		h. Record leakage measurements in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.12	<u>START TANK DISCHARGE VALVE PISTON LIP SEAL LEAK TEST AT KSC ON ENGINES WITH START TANK DISCHARGE VALVE 304386 (MD275 CHANGE)</u>	a. Pressurize helium tank to 600-1,600 psig with helium and ignition-phase control valves energized.		Mainstage control valve may be energized to conserve helium during test.
		b. Measure leakage at STDV control valve vent port with STDV control valve deenergized.	Maximum allowable leakge is 15 scim.	If leakage exceeds limit, steps d and e are required.
		c. Measure leakage at STDV control valve vent port with STDV control valve energized.	Maximum allowable leakage is 15 scim.	If leakage exceeds limit, steps f and g are required.
		d. Measure leakage at STDV control valve vent port with a blocking test plate installed between STDV and opening control line restrictor check valve, and with STDV control valve deenergized.	Maximum allowable leakage is 15 scim.	
		e. Subtract leakage measured in step d from leakage measured in step b to determine STDV closing piston lip seal leakage.	Maximum allowable leakage is 100 scim.	
		f. Measure leakage at STDV control valve vent port with a blocking test plate installed between STDV and opening control line restrictor check valve, and with STDV control valve energized.	Maximum allowable leakage is 15 scim.	
		g. Subtract leakage measured in step f from leakage measured in step c to determine STDV opening piston lip seal leakage.	Maximum allowable leakage is 100 scim.	
		h. Record leakage measurements in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.13	START TANK DISCHARGE VALVE SWING GATE LEAK TEST			On restart-mission engines, this test must be performed at KSC.
				On nonrestart-mission engines, this test is not required to meet Engine Contractor minimum requirements.
				Exhaust system test plates are required for this test.
		a. Measure swing gate leakage with exhaust system pressurized to 30 ±1 psig.	Maximum allowable leakage is 20 scim on restart-mission engines and 200 scim on nonrestart-mission engines.	Exhaust system pressure must not exceed 35 psig.
		b. Measure swing gate leakage with outlet side of STDV swing gate pressurized to 500 (+0, -20) psig if leakage in step a exceeded limit.	Maximum allowable leakage is 20 scim on restart-mission engines and 200 scim on nonrestart-mission engines.	This test is required only if leakage in step a exceeded limit. Test pressure must not exceed 500 psig.
		c. Record leakage measurements in Engine Log Book.		
1.3.14	OXIDIZER TURBOPUMP TORQUE TEST			Turbine wheel must be turned clockwise (viewed from aft end of engine).
		a. Measure breakaway torque.	(1) Maximum allowable torque is 1,000 inch-pounds for SIVB-stage engines and, if hydraulic pump is not installed, also for SII-stage engines.	Torque in excess of 1,000 inch-pounds must not be applied to turbine shaft. When measuring torque with hydraulic pump installed, indicated torque must be converted to actual torque, due to effect of torque wrench adapter.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.13	<u>START TANK DISCHARGE VALVE SWING GATE LEAK TEST</u>			On restart-mission engines, this test must be performed at KSC. On nonrestart-mission engines, this test need be performed only once, either during post-static-test securing and checkout or at KSC. Exhaust system test plates are required for this test.
		a. Measure swing gate leakage with exhaust system pressurized to 30 ±1 psig.	Maximum allowable leakage is 20 scim on restart-mission engines and 200 scim on nonrestart-mission engines.	Exhaust system pressure must not exceed 35 psig.
		b. Measure swing gate leakage with outlet side of STDV swing gate pressurized to 500 (+0, -20) psig if leakage in step a exceeded limit.	Maximum allowable leakage is 20 scim on restart-mission engines and 200 scim on nonrestart-mission engines.	This test is required only if leakage in step a exceeded limit. Test pressure must not exceed 500 psig.
		c. Record leakage measurements in Engine Log Book.		
1.3.14	<u>OXIDIZER TURBOPUMP TORQUE TEST</u>			Turbine wheel must be turned clockwise (viewed from aft end of engine).
		a. Measure breakaway torque.	(1) Maximum allowable torque is 1,000 inch-pounds for SIVB-stage engines and, if hydraulic pump is not installed, also for SII-stage engines.	Torque in excess of 1,000 inch-pounds must not be applied to turbine shaft. When measuring torque with hydraulic pump installed, indicated torque must be converted to actual torque, due to effect of torque wrench adapter.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.14 (cont)			(2) Maximum allowable torque is 500 inch-pounds if hydraulic pump is installed (SII-stage engines only).	If torque exceeds limit, hydraulic pump must be disconnected and torque test repeated, using 1,000 inch-pound limit. When measuring torque with hydraulic pump installed, indicated torque must be converted to actual torque, due to effect of torque wrench adapter.
		b. Measure running torque.	Maximum allowable torque is 200 inch-pounds.	When measuring torque with hydraulic pump installed, indicated torque must be converted to actual torque, due to effect of torque wrench adapter.
		c. Record torque measurements in Engine Log Book.		
1.3.15	<u>FUEL TURBOPUMP TORQUE TEST</u>	a. Measure breakaway torque.	Maximum allowable torque is 1,000 inch-pounds.	Torque in excess of 1,000 inch-pounds must not be applied to turbine shaft. Turbine wheel must be turned counterclockwise (viewed from aft end of engine).
		b. Measure running torque.	Maximum allowable torque is 300 inch-pounds.	
		c. Record torque measurements in Engine Log Book.		
1.3.16	<u>OXIDIZER FEED SYSTEM TEST FOR UNINSTALLED ENGINES</u>			Exhaust system test plates are required for this test.
		a. <u>Connection, Flange Joint, In-Place Tube Weld, and Line Braid Leak Tests.</u> Pressurize oxidizer feed system to 30 ±1 psig.	Leakage is not allowable.	
		b. <u>Oxidizer Turbopump Primary Seal Leakage Measurement.</u>		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.16 (cont)		(1) Pressurize oxidizer feed system to 30 ±1 psig, and observe primary seal leakage while rotating turbine wheel clockwise (as viewed from engine aft end) for 5 rotations minimum; stop rotation at position of maximum leakage.		Torque in excess of 1,000 in-lb must not be applied to turbine shaft.
		(2) Measure primary seal leakage.	Maximum allowable leakage is 350 scim.	
		(3) Measure flow of supply gas into oxidizer feed system.		
		c. <u>Oxidizer Turbopump Shaft Seal and GG Control Valve Oxidizer Poppet Combined Leakage Measurement.</u> Pressurize oxidizer feed system to 30 ±1 psig.	Maximum allowable combined leakage is 1.5 scim.	If leakage exceeds limit, steps d and e are required.
		d. <u>GG Control Valve Oxidizer Poppet Leakage Measurement.</u> Disconnect oxidizer bleed valve and pressurize oxidizer inlet to 30 ±1 psig.	Maximum allowable leakage is 1.5 scim.	
		e. <u>Oxidizer Turbopump Shaft Seal Leakage Determination.</u> Subtract leakage measured in step d from combined leakage measured in step c.	Maximum allowable leakage is 20 scim.	
		eA. <u>On Engines Incorporating MD366 or MD371 change, MRCV Shaft Seal Leakage Measurement.</u> Pressurize oxidizer feed system to 30 ±1 psig, and measure leakage at valve vent port.	Maximum allowable leakage is 10 scim.	
		f. <u>Oxidizer Bleed Valve Leakage Measurement.</u> Pressurize oxidizer feed system to 30 ±1 psig, and pressurize helium tank to 225-250 psig with helium control valve energized.	Maximum allowable leakage is 300 scim.	Purge control valve inlet must be blocked.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.16 (cont)		g. <u>Oxidizer Turbopump Intermediate Seal Purge Flow and Leakage Measurements.</u> Pressurize helium tank to 600 ±25 psig with helium control valve energized for the following purge flow and seal leakage measurements:	Allowable seal purge flow is 2,600-7,000 scim (total of values measured in substeps a through c). Maximum seal leakage (total of substeps a and b) is 850 scim.	Pressure required for this test exceeds personnel safe-operating limits.
		(1) Oxidizer turbopump intermediate seal (pump direction).		
		(2) Oxidizer turbopump intermediate seal (turbine direction).		
		(3) Oxidizer turbopump intermediate seal purge check valve flow.		
		h. <u>Oxidizer Feed System Leakage Determination.</u> Subtract leakages measured in substep 2 of step b and step c from flow measured in substep 3 of step b.	Maximum allowable system leakage is 17 scim.	If leakage of system exceeds limit, turbopump must be rotated several times and steps b and c must be repeated.
		i. Record leakage measurements in Engine Log Book.		
1.3.17	<u>OXIDIZER FEED SYSTEM TEST DURING ENGINE POST-MANUFACTURING CHECKOUT</u>			Pressure used for this test must be between 10 and 35 psig.
		a. <u>Oxidizer Inlet Duct Flange Leak Test (at Customer-Connect Interface).</u> Pressurize oxidizer feed system to maximum stage oxidizer tank pressure capability.	Leakage is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.17 (cont)		b. <u>LOX BLEED LINE Customer-Connect Leak Test.</u> Pressurize oxidizer feed system to maximum stage oxidizer tank pressure capability.		On SII stage engines, stage oxidizer chilldown return system may be closed to pressurize system over stage oxidizer tank pressure. On SIVB stage engines, oxidizer bleed line is leak tested at stage oxidizer tank pressure.
1.3.18	<u>OXIDIZER FEED SYSTEM TEST FOR ENGINE CHECKOUT AT MTF AND SAC/MDAC</u>			Leakage measurements must be recorded for entry in Engine Log Book. Stage oxidizer chilldown return system must be closed and engine must be restrained to prevent gimbaling, before oxidizer feed system is pressurized.
		a. <u>Connection, Flange Joint, In-Place Tube Weld, and Line Braid Leak Tests.</u> Pressurize oxidizer feed system to 30 ±5 psig.	Leakage is not allowable.	
		b. <u>Oxidizer Turbopump Primary Seal Leakage Measurement.</u>		
		(1) Pressurize oxidizer feed system to 30 ±5 psig, and observe primary seal leakage while rotating turbine wheel clockwise (as viewed from engine aft end) for 5 rotations minimum; stop rotation at position of maximum leakage.		Torque in excess of 1,000 inch-pounds must not be applied to turbine shaft.
		(2) Measure primary seal leakage.	Maximum allowable leakage is 350 scim.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.18 (cont)		c. Oxidizer Turbopump Shaft Seal and GG Control Valve Oxidizer Poppet Combined Leakage Measurement. Pressurize oxidizer feed system to 30 ±5 psig.	Maximum allowable combined leakage is 1.5 scim.	Oxidizer turbopump shaft seal and GG control valve oxidizer poppet combined leakage measurement is not required to meet Engine Contractor minimum requirements.
		d. CG Control Valve Oxidizer Poppet Leakage Measurement. Disconnect oxidizer bleed valve and pressurize oxidizer inlet to 30 ±5 psig.	Maximum allowable leakage is 1.5 scim.	
		e. Oxidizer Turbopump Shaft Seal Leakage Determination. Subtract leakage measured in step d from combined leakage measured in step c.	Maximum allowable leakage is 20 scim.	
		f. On Engines Not Incorporating MD366 or MD371 Change. PU Valve Shaft Seal Leakage Measurement. Pressurize oxidizer feed system to 30 ±5 psig, and measure leakage at PU valve vent port.	Maximum allowable leakage is 10 scim.	PU valve shaft seal leakage measurement is not required to meet Engine Contractor minimum requirements.
		g. MOV Gate Seal and ASI Valve Seat Combined Leakage Measurement. Pressurize oxidizer feed system to 30 ±5 psig, and measure leakage at throat plug test port.	Maximum allowable leakage is 10 scim.	MOV gate seal and ASI valve seat leakage measurement is not required to meet Engine Contractor minimum requirements. Thrust chamber throat plug is required for this test. Stage fuel tank pressurization system must be isolated from engine. Allow 5 minutes minimum to elapse from time system is pressurized until measurement is made. If leakage exceeds limit, steps h and i are required.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.18 (cont)		h. MOV Gate Seal Leakage Measurement. Block ASI valve oxidizer outlet connection to ASI oxidizer line and repeat test requirement of step g.	Maximum allowable leakage is 10 scim.	Allow 5 minutes minimum to elapse from time system is pressurized until measurement is made.
		i. ASI Valve Seat Leakage Determination. Subtract leakage measured in step h from combined leakage measured in step g.	Maximum allowable leakage is 10 scim.	
		j. Oxidizer Bleed Valve Leakage Measurement. Pressurize oxidizer feed system to 30 ±5 psig, and pressurize helium tank to 225-250 psig with helium control valve energized.	Maximum allowable leakage is 300 scim.	Source of leakage must be verified as not originating from sta e oxidizer chilldown return system. Purge control valve inlet must be blocked.
		k. Oxidizer Turbopump Intermediate Seal Purge Flow and Leakage Measurements. (Use substep 1 or 2.)		
		(1) Pressurize helium tank until helium regulator out pressure of 225-250 psia is obtained. With helium control valve energized, check the following purge flow and seal leakage measurements:	Allowable seal purge flow is 1,500 scim minimum (total of values measured in substeps a through c. Maximum seal leakage (total of substeps a and b) is 850 scim.	
		(a) Oxidizer turbopump intermediate seal (pump direction).		
		(b) Oxidizer turbopump intermediate seal (turbine direction).		
		(c) Oxidizer turbopump intermediate seal purge check valve flow.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.18 (cont)		(2) Pressurize helium tank to 600 ±25 psig with helium control valve energized for the following purge flow and seal leakage measurements: (a) Oxidizer turbopump intermediate seal (pump direction). (b) Oxidizer turbopump intermediate seal (turbine direction). (c) Oxidizer turbopump intermediate seal purge check valve flow.	Allowable seal purge flow is 2,600-7,000 scim (total of values measured in substeps a through c). Maximum seal leakage (total of substeps a and b) is 850 scim.	Pressure required for performing this test exceeds personnel safe-operating limits.
		l. Record leakage measurements in Engine Log Book.		
1.3.19	<u>OXIDIZER FEED SYSTEM TEST FOR ENGINE CHECK-OUT AT KSC</u>			Exhaust system test plates are required for this test. Stage oxidizer chilldown return system must be closed and engine must be restrained to prevent gimbaling, before oxidizer feed system is pressurized. Leakage measurements must be recorded for entry in Engine Log Book.
		a. <u>Separable Flange Joint Leak Tests.</u> Pressurize oxidizer feed system to 30 ±5 psig.	Leakage is not allowable.	
		b. <u>Oxidizer Turbopump Primary Leakage Measurement.</u>		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.19 (cont)		(1) Pressurize oxidizer feed system to 30 ±5 psig. and observe primary seal leakage while rotating turbine wheel clockwise (as viewed from engine aft end) for 5 rotations minimum; stop rotation at position of maximum leakage.		Torque in excess of 1,000 inch-pounds must not be applied to turbine shaft.
		(2) Measure primary seal leakage.	Maximum allowable leakage is 350 scim.	
		c. <u>Oxidizer Turbopump Shaft Seal and GG Control Valve Oxidizer Poppet Combined Leakage Measurement.</u> Pressurize oxidizer feed system to 30 ± 5 psig.	Maximum allowable combined leakage is 1.5 scim.	If leakage exceeds limit, steps d and e are required.
		d. <u>GG Control Valve Oxidizer Poppet Leakage Measurement.</u> Disconnect oxidizer bleed valve and pressurize oxidizer inlet to 30 ±5 psig.	Maximum allowable leakage is 1.5 scim.	
		e. <u>Oxidizer Turbopump Shaft Seal Leakage Determination.</u> Subtract leakage measured in step d from combined leakage measured in step c.	Maximum allowable leakage is 20 scim.	
		f. <u>PU Valve or MRCV Shaft Seal Leakage Measurement.</u> Pressurize oxidizer feed system to 30 ±5 psig, and measure leakage at valve vent port.	Maximum allowable leakage is 10 scim.	MRCV shaft seal must be leak tested with oxidizer feed system pressurized to 30 (+5, -1) psig before replacing MRCV for excessive shaft seal leakage.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.19 (cont)		g. MOV Gate Seal and ASI Valve Seat Combined Leakage Measurement. Pressurize oxidizer feed system to 30 ±5 psig, and measure leakage at throat plug test port.	Maximum allowable leakage is 10 scim.	MOV gate seal and ASI valve seat leakage measurement is not required to meet Engine Contractor minimum requirements. Thrust chamber throat plug is required for this test. Stage fuel tank pressurization system must be isolated from engine. Allow 5 minutes minimum to elapse from time system is pressurized until measurement is made. If leakage exceeds limit, steps h and i are required.
		h. MOV Gate Seal Leakage Measurement. Block ASI valve oxidizer outlet connection to ASI oxidizer line, and repeat test requirement of step g.	Maximum allowable leakage is 10 scim.	Allow 5 minutes minimum to elapse from time system is pressurized until measurement is made.
		i. ASI Valve Seat Leakage Determination. Subtract leakage measured in step h from combined leakage measured in step g.	Maximum allowable leakage is 10 scim.	
		j. Oxidizer Bleed Valve Leakage Measurement. Pressurize oxidizer feed system to 30 ±5 psig, and pressurize helium tank to 600-1,600 psig with helium control valve energized.	Maximum allowable leakage is 300 scim.	Oxidizer bleed valve leakage measurement is not required to meet Engine Contractor minimum requirements. Source of leakage must be verified as not originating from stage oxidizer chilldown return system. Purge control valve inlet must be blocked.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.19 (cont)		k. Oxidizer Turbopump Intermediate Seal Purge Flow. Verify flow from oxidizer turbopump intermediate seal purge check valve with helium tank pressurized to 600-1,600 psig and helium control valve energized.	Helium must flow from check valve exit line.	
		l. Oxidizer Turbopump Intermediate Seal Leakage Measurements. Pressurize helium tank to 600-1,600 psig with helium control valve energized for the following seal leakage measurements:	Maximum allowable seal leakage (total of substeps 1 and 2) is 850 scim.	Purge control valve inlet must be blocked.
		(1) Oxidizer turbopump intermediate seal (pump direction).		
		(2) Oxidizer turbopump intermediate seal (turbine direction).		
		m. Record leakage measurements in Engine Log Book.		
1.3.20	OXIDIZER TURBOPUMP PRIMARY SEAL DRAIN LINE BURST DIAPHRAGM LEAK TEST	Evacuate drain line from exit end, using test fixture KSC-J2-R066967.	Leakage is not allowable.	Indicator pin on test fixture must retract.
1.3.21	FUEL FEED SYSTEM TEST FOR UNISTALLED ENGINES			Exhaust system test plates are required for this test.
		a. Connection, Flange Joint, In-Place Tube Weld, and Line Braid Leak Tests. Pressurize fuel feed system to 30 ±1 psig.	Leakage is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.21 (cont)		b. Turbopump Primary Seal Leakage Measurement.		
		(1) Pressurize fuel feed system to 30 ±1 psig, and observe primary seal leakage while rotating turbine wheel counterclockwise (as viewed from engine aft end) for 5 rotations minimum; stop rotation at position of maximum leakage.		Torque in excess of 1,000 in-lb must not be applied to turbine shaft.
		(2) Measure primary seal leakage.	Maximum allowable leakage is 350 scim.	Combined leakage of fuel turbopump primary and secondary seals must be within limits of figure 1-9.
		(3) Measure flow of supply gas into fuel feed system.		
		c. Fuel Turbopump Omni Seal and GG Control Valve Fuel Poppet Combined Leakage Measurement. Pressurize fuel feed system to 30 ±1 psig.	Maximum allowable combined leakage is 15 scim.	
		d. Fuel Bleed Valve Leakage Measurements. Pressurize fuel feed system to 30 ±1 psig, and pressurize helium tank to 225-250 psig with helium control valve energized.	Maximum allowable leakage is 300 scim.	Purge control valve inlet must be blocked.
		e. Fuel Feed System Leakage Determination. Subtract leakages measured in substep 2 of step b and step c from flow measured in substep 3 of step b.	Maximum allowable system leakage is 12 scim.	
		f. Record leakage measurements in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.22	FUEL FEED SYSTEM TEST DURING ENGINE POST-MANUFACTURING CHECKOUT			Pressure used for this test must be between 10 and 35 psig.
		a. Fuel Inlet Duct Flange Leak Test (at Customer-Connect Interface). Pressurize fuel feed system to maximum stage fuel tank pressure capability.	Leakage is not allowable.	
		b. FUEL BLEED LINE Customer-Connect Leak Test. Pressurize fuel feed system to maximum stage fuel tank pressure capability.	Leakage is not allowable.	On SII stage engines, stage fuel chilldown return system may be closed to pressurize system over stage fuel tank pressure. On SIVB stage engines, fuel bleed line is leak tested at stage fuel tank pressure.
1.3.23	FUEL FEED SYSTEM TEST FOR ENGINE CHECKOUT AT MTF AND SAC/MDAC			Leakage measurements must be recorded for entry in Engine Log Book. Stage fuel chilldown return system must be closed and engine must be restrained to prevent gimbaling, before fuel feed system is pressurized.
		a. Connection, Flange Joint, In-Place Tube Weld, and Line Braid Leak Tests. Pressurize fuel feed system to 30 ±5 psig.	Leakage is not allowable.	
		b. Fuel Turbopump Primary Seal Leakage Measurement.		
		(1) Pressurize fuel feed system to 30 ±5 psig, and observe primary seal leakage while rotating turbine wheel counterclockwise (as viewed from engine aft end) for 5 rotations minimum; stop rotation at position of maximum leakage.		Torque in excess of 1,000 inch-pounds must not be applied to turbine shaft.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.23 (cont)		(2) Measure primary seal leakage.	Combined leakage of fuel turbopump primary and secondary seals must be within limits of figure 1-9 for SII-stage engines or figure 1-10 for SIVB-stage engines.	
		c. <u>Fuel Turbopump Omni Seal and GG Control Valve Fuel Poppet Combined Leakage Measurement.</u> Pressurize fuel feed system to 30 ±5 psig.	Maximum allowable combined leakage is 15 scim.	Fuel turbopump omni seal and GG control valve fuel poppet combined leakage measurement is not required to meet Engine Contractor minimum requirements.
		d. <u>MFV Gate Seal Leakage Measurement.</u> Pressurize fuel feed system to 30 ±5 psig, and measure leakage at throat plug test port.	Maximum allowable leakage is 10 scim.	MFV gate seal leakage measurement is not required to meet Engine Contractor minimum requirements. Thrust chamber throat plug is required for this test. Stage fuel tank pressurization system must be isolated from engine. Allow 5 minutes minimum to elapse from time system is pressurized until measurement is made.
		e. <u>Fuel Bleed Valve Leakage Measurement.</u> Pressurize fuel feed system to 30 ±5 psig, and pressurize helium tank to 225-250 psig with helium control valve energized.	Maximum allowable leakage is 300 scim.	Source of leakage must be verified as not originating from stage fuel chilldown return system.
		f. Record leakage measurements in Engine Log Book.		
1.3.24	<u>FUEL FEED SYSTEM TEST FOR ENGINE CHECKOUT AT KSC</u>			Exhaust system test plates are required for this test. Stage fuel chilldown return system must be closed and engine must be restrained to prevent gimbaling, before fuel feed system is pressurized. Leakage measurements must be recorded for entry in Engine Log Book.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.24 (cont)		a. Separable Flange Joint Leak Tests. Pressurize fuel feed system to 30 ±5 psig.	Leakage is not allowable.	
		b. Fuel Turbopump Primary Seal Leakage Measurement		
		(1) Pressurize fuel feed system to 30 ±5 psig, and observe primary seal leakage while rotating turbine wheel counterclockwise (as viewed from engine aft end) for 5 rotations minimum; stop rotation at position of maximum leakage.		Torque in excess of 1,000 inch-pounds must not be applied to turbine shaft.
		(2) Measure primary seal leakage.	Combined leakage of fuel turbopump primary and secondary seals must be within limits of figure 1-9 for SII-stage engines or figure 1-10 for SIVB-stage engines.	
		c. Fuel Turbopump Omni Seal and GG Control Valve Fuel Poppet Combined Leakage Measurement. Pressurize fuel feed system to 30 ±5 psig.	Maximum allowable combined leakage is 15 scim.	
		d. MFV Gate Seal Leakage Measurement. Pressurize fuel feed system to 30 ±5 psig, and measure leakage at throat plug test port.	Maximum allowable leakage is 10 scim.	MFV gate seal leakage measurement is not required to meet Engine Contractor minimum requirements. Thrust chamber throat plug is required for this test. Stage fuel tank pressurization system must be isolated from engine. Allow 5 minutes minimum to elapse from time system is pressurized until measurement is made.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.24 (cont)		e. Fuel Bleed Valve Leakage Measurement. Pressurize fuel feed system to 30 ±5 psig, and pressurize helium tank to 600-1,600 psig with helium control valve energized.	Maximum allowable leakage is 300 scim.	Fuel bleed valve leakage measurement is not required to meet Engine Contractor minimum requirements. Source of leakage must be verified as not originating from stage fuel chilldown return system. Purge control valve inlet must be blocked.
		f. Record leakage measurements in Engine Log Book.		
1.3.25	FUEL TURBOPUMP SECONDARY SEAL LEAK TEST FOR UNINSTALLED ENGINES	a. Pressurize fuel turbopump primary seal cavity to 30 ±1 psig, and observe secondary seal leakage while rotating turbine wheel counterclockwise (as viewed from engine aft end) for 5 rotations minimum; stop rotation at position of maximum leakage and measure secondary seal leakage.	Maximum allowable leakage is 500 scim, and combined leakage of fuel turbopump primary and secondary seals must be within limits of figure 1-9.	Torque in excess of 1,000 in-lb must not be applied to turbine shaft.
		b. Record leakage measurement in Engine Log Book.		
1.3.26	FUEL TURBOPUMP SECONDARY SEAL LEAK TEST FOR INSTALLED ENGINES	a. Pressurize fuel turbopump primary seal cavity to 30 ±1 psig, and observe secondary seal leakage while rotating turbine wheel counterclockwise (as viewed from engine aft end) for 5 rotations minimum; stop rotation at position of maximum leakage and measure secondary seal leakage.	Combined leakage of fuel turbopump primary and secondary seals must be within limits of figure 1-9 for SII-stage engines or figure 1-10 for SIVB-stage engines.	Torque in excess of 1,000 in-lb must not be applied to turbine shaft.
		b. Record leakage measurement in Engine Log Book.		
1.3.27	PURGE SYSTEM TEST FOR UNINSTALLED ENGINES			Exhaust system test plates are required for this test. On engines incorporating MD234 change, STDV drain port to drain line connection must be blocked.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.27 (cont)		a. Purge System Flow Measurements. Measure the following purge flows with purge system pressurized to 68 ±1 psig at customer connect:	Minimum Allowable Purge Flow Limits (scim)	
		(1) Oxidizer turbine seal purge flow.	2,400	
		(2) Fuel turbine seal purge flow.	2,400	
		(3) Fuel turbopump primary seal purge flow.	200	
		(4) GG fuel purge flow.	2,400	
		b. Purge System Total Flow Determination. Calculate sum of purge flow values measured in step a.	Maximum allowable flow is 10,368 scim.	
		c. Purge System Leak Tests. Leak-test purge lines from customer connect to oxidizer turbopump, fuel turbopump (2 lines), and GG with purge system pressurized to 68 ±1 psig at customer connect.	Leakage is not allowable.	
		d. Record purge flows in Engine Log Book.		
1.3.28	PURGE SYSTEM TEST FOR INSTALLED ENGINES			Verification of gas flow from all four legs of the purge system is an acceptable alternate to measuring flow, if interface pressure requirements are met.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.28 (cont)		a. <u>Purge System Flow Measurements.</u> Measure the following purge flows with purge system pressurized to 67-115 psig:	<u>Minimum Allowable Purge Flow Limits (scim)</u>	If purge flows are not within limits, STDV drain port to drain line connection (on engines incorporating MD<u>234</u> change) or STDV drain line to thrust chamber exhaust manifold connection (on engines not incorporating MD<u>234</u> change) must be blocked and purge flow measurements repeated.
		(1) Oxidizer turbine seal purge.	2,400	
		(2) Fuel turbine seal purge flow.	2,400	
		(3) Fuel turbopump primary seal purge flow.	200	
		(4) GG fuel purge flow.	2,400	
		b. Record test results in Engine Log Book.		
		c. <u>Purge System Leak Tests.</u> Leak-test purge lines from customer connect to oxidizer turbopump, fuel turbopump (2 lines), and GG with purge system pressurized to 67-115 psig.	Leakage is not allowable.	Purge system leak tests are not required to meet Engine Contractor minimum requirements.
1.3.29	<u>PURGE MANIFOLD SYSTEM CUSTOMER-CONNECT LEAK TEST</u>	Leak-test PURGE MANIFOLD SYSTEM customer connect with purge system pressurized to 67-115 psig.	Leakage is not allowable.	
1.3.30	<u>FUEL TURBOPUMP PRIMARY SEAL DRAIN CUSTOMER-CONNECT LEAK TEST</u>	Leak-test FUEL PUMP DRAIN customer connect with fuel turbopump (primary seal) drain customer-connect line pressurized to 30 ±1 psig.	Leakage is not allowable.	
1.3.31	<u>OXIDIZER TURBOPUMP INTERMEDIATE SEAL PURGE CHECK VALVE REVERSE-LEAK TEST</u>	Measure reverse leakage with downstream side of check valve pressurized to 30 ±1 psig.	Maximum allowable leakage is 25 scim.	This measurement is based on the use of a pneumatic flowmeter in line with the pneumatic pressure source.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.32	FUEL TURBINE SEAL PURGE CHECK VALVE REVERSE-LEAK TEST			Gas generator and exhaust system must be vented to atmosphere. On engines incorporating MD234 change, STDV drain port to drain line connection must be blocked.
		a. Check Valve Reverse-Leakage Measurement. Pressurize fuel turbine seal drain line to 30 ±1 psig.	Maximum allowable leakage is 100 scim.	
		b. Record leakage measurement in Engine Log Book.		
		c. Fuel Turbine Seal Drain Line Leak Test. Pressurize drain line to 30 ±1 psig.	Leakage is not allowable.	
1.3.33	OXIDIZER TURBINE SEAL PURGE CHECK VALVE REVERSE-LEAK TEST	a. Check Valve Reverse-Leakage Measurement. Pressurize oxidizer turbine seal drain line to 30 ±1 psig.	Maximum allowable leakage is 100 scim.	Helium, ignition-phase, and mainstage control valves must be energized and helium tank pressurized to prevent backflow through the helium regulator.
		b. Record leakage measurement in Engine Log Book.		
		c. Oxidizer Turbine Seal Drain Line Leak Test. Pressurize drain line to 30 ±1 psig.	Leakage is not allowable.	
1.3.34	OXIDIZER TURBOPUMP PRIMARY SEAL DRAIN LINE LEAK TEST	Leak-test drain line according to requirements in paragraph 1.3.34.1 or 1.3.34.2,as applicable.		Helium, ignition-phase, and mainstage control valves must be energized and helium tank pressurized to prevent backflow through the helium regulator.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.32	FUEL TURBINE SEAL PURGE CHECK VALVE REVERSE-LEAK TEST			Gas generator and exhaust system must be vented to atmosphere. On engines incorporating MD234 change, STDV drain port to drain line connection must be blocked.
		a. Check Valve Reverse-Leakage Measurement. Pressurize fuel turbine seal drain line to 30 ±1 psig.	Maximum allowable leakage is 100 scim.	
		b. Record leakage measurement in Engine Log Book.		
		c. Fuel Turbine Seal Drain Line Leak Test. Pressurize drain line to 30 ±1 psig.	Leakage is not allowable.	
1.3.33	OXIDIZER TURBINE SEAL PURGE CHECK VALVE REVERSE-LEAK TEST	a. Check Valve Reverse-Leakage Measurement. Pressurize oxidizer turbine seal drain line to 30 ±1 psig.	Maximum allowable leakage is 100 scim.	Helium, ignition-phase, and mainstage control valves must be energized and helium tank pressurized to 225-250 psig at HB, SB, MTF and SAC/MDAC, or 600-1,600 psig at KSC.
		b. Record leakage measurement in Engine Log Book.		
		c. Oxidizer Turbine Seal Drain Line Leak Test. Pressurize drain line to 30 ±1 psig.	Leakage is not allowable.	
1.3.34	OXIDIZER TURBOPUMP PRIMARY SEAL DRAIN LINE LEAK TEST	Leak-test drain line according to requirements in paragraph 1.3.34.1, 1.3.34.2, or 1.3.34.3, as applicable.		Helium, ignition-phase, and mainstage control valves must be energized and helium tank pressurized to 225-250 psig at HB, SB, MTF and SAC/MDAC, or 600-1,600 psig at KSC.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.34.1	Oxidizer Turbopump Primary Seal Drain Line Leak Test at KSC	Leak-test the following lines with primary seal drain line (at thrust chamber exit) pressurized to 30 ±1 psig:		Burst diaphragm must not be installed on drain line.
		a. Oxidizer turbopump primary seal drain line connections and welds.	Leakage is not allowable.	
		b. OXIDIZER PUMP PRIMARY SEAL DRAIN customer-connect line braided section.	Leakage is not allowable.	
		c. Oxidizer turbopump primary seal cavity pressure (PO6) instrumentation line from turbopump to auxiliary F1 package and (on engines not incorporating MD150 change) to static-test transducer.	Leakage is not allowable.	
1.3.34.2	Oxidizer Turbopump Primary Seal Drain Line Leak Test During Post-Manufacturing Checkout	Leak-test OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect with drain line (at thrust chamber exit) pressurized to 30 ±1 psig.	Leakage is not allowable.	Burst diaphragm must not be installed on drain line.
1.3.35	FUEL TURBOPUMP PRIMARY SEAL DRAIN CHECK VALVE REVERSE-LEAK TEST	a. Check Valve Reverse-Leakage Measurement. Pressurize fuel turbopump primary seal drain customer-connect line to 30 ±1 psig.	Maximum allowable leakage is 25 scim.	
		b. Record leakage measurement in Engine Log Book.		
		c. Fuel Turbopump Primary Seal Drain Line Leak Test. Leak-test drain line from check valve to customer connect with customer-connect line pressurized to 30 ±1 psig.	Leakage is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
		d. Start Tank Emergency Vent Valve Drain Line (on Engines Incorporating MD320 or MD351 Change). Leak-test drain line from emergency vent valve to tee at fuel primary seal drain line with customer-connect line pressurized to 30 ±1 psig.	Leakage is not allowable.	
1.3.36	FUEL TURBOPUMP PRIMARY SEAL PURGE CHECK VALVE REVERSE-LEAK TEST	Measure check valve reverse leakage with fuel turbopump primary seal cavity pressurized to 30 ±1 psig. Record leakage measurement in Engine Log Book.	Maximum allowable leakage is 100 scim.	
1.3.37	FUEL TURBOPUMP PRIMARY SEAL DRAIN CHECK VALVE FLOW TEST	a. Check Valve Forward Leakage Measurement. Pressurize fuel turbopump primary seal cavity to 30 ±1 psig.	Maximum allowable forward leakage is 30 scim.	Pressure must be applied and measured at boss between drain check valve and turbopump.
		b. Leak-test drain line from fuel turbopump to upstream side of check valve with line pressurized to 30 ±1 psig.	Leakage is not allowable.	
		c. Check Valve Flow Measurement. Pressurize fuel turbopump primary seal cavity to 60 ±2 psig.	Minimum allowable flow is 2,420 scim.	Pressure must be applied and measured at boss between drain check valve and turbopump.
		d. Record leakage measurements in Engine Log Book.		
1.3.38	GAS GENERATOR OXIDIZER PURGE CHECK VALVE REVERSE-LEAK TEST	a. Measure check valve reverse leakage with downstream side of check valve pressurized to 30 ±5 psig.	Maximum allowable leakage is 15 scim.	
		b. Record leakage measurement in Engine Log Book.		
		c. After removal of test plate and reconnection of flange joint downstream of GG oxidizer purge check valve, inspect 4 bolts for proper length.	A minimum of one full thread must protrude beyond top of nut.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.35	FUEL TURBOPUMP PRIMARY SEAL DRAIN CHECK VALVE REVERSE-LEAK TEST	a. Check Valve Reverse-Leakage Measurement. Pressurize fuel turbopump primary seal drain customer-connect line to 30 ±1 psig.	Maximum allowable leakage is 25 scim.	
		b. Record leakage measurement in Engine Log Book.		
		c. Fuel Turbopump Primary Seal Drain Line Leak Test. Leak-test drain line from check valve to customer connect with customer-connect line pressurized to 30 ±1 psig.	Leakage is not allowable.	
		d. Start Tank Emergency Vent Valve Drain Line (on Engines Incorporating MD320 or MD351 Change). Leak-test drain line from emergency vent valve to tee at fuel primary seal drain line with customer-connect line pressurized to 30 ±1 psig.	Leakage is not allowable.	
1.3.36	FUEL TURBOPUMP PRIMARY SEAL PURGE CHECK VALVE REVERSE-LEAK TEST	Measure check valve reverse leakage with fuel turbopump primary seal cavity pressurized to 30 ±1 psig. Record leakage measurement in Engine Log Book.	Maximum allowable leakage is 100 scim.	
1.3.37	FUEL TURBOPUMP PRIMARY SEAL DRAIN CHECK VALVE FLOW TEST	a. Check Valve Forward Leakage Measurement. Pressurize fuel turbopump primary seal cavity to 30 ±1 psig.	Maximum allowable forward leakage is 30 scim.	Pressure must be applied and measured at boss between drain check valve and turbopump.
		b. Leak-test drain line from fuel turbopump to upstream side of check valve with line pressurized to 30 ±1 psig.	Leakage is not allowable.	
		c. Check Valve Flow Measurement. Pressurize fuel turbopump primary seal cavity to 60 ±2 psig.	Minimum allowable flow is 2,420 scim.	Pressure must be applied and measured at boss between drain check valve and turbopump.
		d. Record leakage measurements in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.38A	REDUNDANT PURGE CHECK VALVE REVERSE-LEAK TEST	a. Measure check valve reverse leakage with downstream side of check valve pressurized to 30 ±5 psig.	Maximum allowable leakage is 30 scim.	
		b. Record leakage measurement in Engine Log Book.		
1.3.39	MAIN OXIDIZER VALVE SEQUENCE CONTROL VALVE LIP SEAL LEAK TEST	Measure the following leakages with helium control valve energized and helium tank pressurized to a minimum of 630 psig to maintain helium regulator outlet pressure of 375-425 psig:		Leakage must be measured at GG control valve vent port with pneumatic flowmeter positioned far enough from engine to satisfy site safety requirements. Flowmeter indication must be stabilized before measurement is recorded.
		a. Combined MOV Sequence Control Valve Lip Seal and OTBV Piston Lip Seal (Opening Pressure) Leakage Measurement. Energize ignition-phase control valve.	Maximum allowable leakage is 5 scim.	If leakage exceeds limit, steps b and c are required.
		b. OTBV Piston Lip Seal (Opening Pressure) Leakage Measurement. De-energize ignition-phase control valve.	Maximum allowable leakage is 10 scim.	
		c. MOV Sequence Control Valve Lip Seal Leakage Determination. Subtract leakage measured in step b from combined leakage (step a).	Maximum allowable leakage is 5 scim.	
		d. Record leakage measurements in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.40	GAS GENERATOR EQUALIZATION LINE LEAK TEST	Leak-test connections and welds of equalization line from GG to MOV sequence valve with GG control valve vent port pressurized to 30 ±1 psig.	Leakage is not allowable.	
1.3.41	PNEUMATIC CONTROL SYSTEM TEST FOR UNINSTALLED ENGINES	a. Pneumatic Control System Connection and Joint Leak Tests. Leak-test helium fill line, check valve, tank, and regulator control and instrumentation connections, flange joints, seals, line welds and flex line braid, as applicable, for lines, ports, and connections pressurized when the following control valves are energized and helium tank is pressurized to 225-250 psig:		Purge control valve inlet line to inlet port connection must be blocked. Correct electrical and pneumatic operation of control valves must be verified. Intermediate seal purge vent gas must be directed away from engine for leak-detector test of flex line braid.
		(1) Helium control valve energized.	Leakage is not allowable.	
		(2) Helium and ignition-phase control valves energized.	Leakage is not allowable.	
		(3) Helium, ignition-phase, and STDV control valves energized.	Leakage is not allowable.	Start tank pressure must be zero before STDV control valve is energized.
		(4) Helium, ignition-phase, and mainstage control valves energized.	Leakage is not allowable.	
		b. Fast-Shutdown Valve Diaphragm Leakage Measurement.		Purge control valve inlet line to inlet port connection must be blocked.
		(1) Energize helium control valve, pressurize helium tank to 225-250 psig, and measure leakage at fast-shutdown valve vent port.	Maximum allowable leakage is 3 scim.	Correct electrical and pneumatic operation of control valves must be verified. If leakage exceeds limit, substep 2 is required.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.40	<u>GAS GENERATOR EQUALIZATION LINE LEAK TEST</u>	Leak-test connections and welds of equalization line from GG to MOV sequence valve with GG control valve vent port pressurized to 30 ±1 psig.	Leakage is not allowable.	
1.3.41	<u>PNEUMATIC CONTROL SYSTEM TEST FOR UNINSTALLED ENGINES</u>	a. <u>Pneumatic Control System Connection and Joint Leak Tests.</u> Leak-test helium fill line, check valve, tank, and regulator control and instrumentation connections, flange joints, seals, line welds and flex line braid, as applicable, for lines, ports, and connections pressurized when the following control valves are energized and helium tank is pressurized to 225-250 psig:		Purge control valve inlet line to inlet port connection must be blocked. Correct electrical and pneumatic operation of control valves must be verified. Intermediate seal purge vent gas must be directed away from engine for leak-detector test of flex line braid.
		(1) Helium control valve energized.	Leakage is not allowable.	
		(2) Helium and ignition-phase control valves energized.	Leakage is not allowable.	
		(3) Helium, ignition-phase, and STDV control valves energized.	Leakage is not allowable.	Start tank pressure must be zero before STDV control valve is energized.
		(4) Helium, ignition-phase, and mainstage control valves energized.	Leakage is not allowable.	
		b. <u>Fast-Shutdown Valve Diaphragm Leakage Measurement.</u>		Purge control valve inlet line to inlet port connection must be blocked.
		(1) Energize helium control valve, pressurize helium tank to 225-250 psig, and measure leakage at fast-shutdown valve vent port.	Maximum allowable leakage is 3 scim.	Correct electrical and pneumatic operation of control valves must be verified. If leakage exceeds limit, substep 2 is required.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.41 (cont)		(2) Remove vent port check valve from GG control valve adjustment plate, energize helium and mainstage control valves, pressurize helium tank to 225-250 psig, and measure leakage at fast-shutdown valve vent port.	Maximum allowable leakage is 3 scim.	
		c. Pneumatic Control System Leakage Measurements. Measure the following leakages with applicable control valves energized and helium tank pressurized to 225-250 psig:		Purge control valve inlet line to inlet port connection must be blocked. Correct electrical and pneumatic operation of control valves must be verified.
		(1) Purge control valve diaphragm leakage with helium control valve energized.	Maximum allowable leakage is 3 scim.	
		(2) STDV control valve vent port leakage with helium, ignition-phase, and STDV control valves energized.	Maximum allowable leakage is 15 scim.	Start tank pressure must be zero before STDV control valve is energized.
		(3) Fast-shutdown valve seat leakage with helium, ignition-phase, and mainstage control valves energized.	Maximum allowable leakage is 10 scim.	
		d. Purge Control Valve Leakage Measurements. Measure the following leakages with helium and mainstage control valves energized and helium tank pressurized to 225-250 psig:		Purge control valve inlet block must be removed and inlet line correctly reinstalled.
		(1) Purge control valve seat leakage.	Maximum allowable leakage is 10 scim.	Leakage measurement is made at purge control valve vent line exit or, on engines incorporating MD166 change but not incorporating MD301, MD302, MD322, or MD323 change, at purge control valve vent port.

Paragraph	Activities		Requirements	Limits	Special Constraints and Remarks
1.3.41 (cont)			(2) Purge control valve inlet flange connection.	Leakage is not allowable.	
		e.	Purge Control Valve Function and Purge Line Leak Test. Actuate purge control valve and leak-test valve outlet flange connection and purge line welds, connections, joints, and seals with helium control valve energized, mainstage control valve deenergized, and helium tank pressurized to 225-250 psig.	Purge control valve actuation (purge flow on) must be verified. Leakage is not allowable.	
		eA.	On Engines Incorporating MD366 or MD371 Change, MRCV Actuator Piston Seal Leakage Measurement. Measure leakage at MRCV vent port with helium control valve, mainstage control valve, and MRCV control solenoid energized and with helium tank pressurized to 225-250 psig.	Maximum allowable leakage is 20 scim.	If purge control valve inlet port is blocked, mainstage control valve does not have to be energized.
		f.	Determine if flange joint downstream of GG oxidizer purge check valve was disconnected for this test. If disconnected, inspect the 4 bolts for proper length after reconnection.	A minimum of one full thread must protrude beyond top of nut.	
		g.	Record leakage measurements in Engine Log Book.		
1.3.42	PNEUMATIC CONTROL SYSTEM TEST DURING ENGINE POST-MANUFACTURING CHECKOUT	a.	HELIUM TANK FILL Customer-Connect Leak Test. Pressurize helium tank to 1,500 ±100 psig.	Leakage is not allowable.	
		b.	Helium Tank Emergency Vent Valve Function Test. Actuate emergency vent valve with helium tank pressurized to 100 psig minimum.	Helium tank pressure must vent.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.43	<u>PNEUMATIC CONTROL SYSTEM TEST FOR ENGINE CHECKOUT AT MTF AND SAC/MDAC</u>			Successful completion of helium usage test and helium supply system pressure-decay test waives requirement to leak-test the pneumatic control system. Except on restart or anticipated high-helium-usage mission engines, helium fill customer-connect flange and helium fill line must be leak tested.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.43 (cont)				Leakage measurements must be recorded for entry in Engine Log Book.
		a. <u>Pneumatic Control System Connection and Joint Leak Tests.</u> Leak-test helium fill line, check valve, tank, and regulator control and instrumentation connections, flange joints, seals, line welds and flex line braid, as applicable, for lines, ports, and connections pressurized when the following control valves are energized and helium tank is pressurized to 225-250 psig:		Purge control valve inlet line to inlet port connection must be blocked. Correct electrical and pneumatic operation of control valves must be verified. Intermediate seal purge vent gas must be directed away from engine for leak-detector test of flex line line braid.
		(1) Helium control valve energized.	Leakage is not allowable.	
		(2) Helium and ignition-phase control valves energized.	Leakage is not allowable.	
		(3) Helium, ignition-phase, and STDV control valves energized.	Leakage is not allowable.	Start tank pressure must be zero before STDV control valve is energized.
		(4) Helium, ignition-phase and mainstage control valves energized.	Leakage is not allowable.	
		b. <u>Fast-Shutdown Valve Diaphragm Leakage Measurement.</u>		Fast-shutdown valve diaphragm leakage measurement is not required to meet Engine Contractor minimum requirements. Purge control valve inlet line to inlet port connection must be blocked. Correct electrical and pneumatic operation of control valves must be verified.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.43 (cont)		(1) Energize helium control valve, pressurize helium tank to 225-250 psig, and measure leakage at fast-shutdown valve vent port.	Maximum allowable leakage is 3 scim.	If leakage exceeds limit, substep 2 is required.
		(2) Remove vent port check valve from GG control valve adjustment plate, energize helium and mainstage control valves, pressurize helium tank to 225-250 psig, and measure leakage at fast-shutdown valve vent port.	Maximum allowable leakage is 3 scim.	
		c. <u>Pneumatic Control System Leakage Measurements.</u> Measure the following leakages with applicable control valves energized and helium tank pressurized to 225-250 psig:		Pneumatic control system leakage measurements are not required to meet Engine Contractor minimum requirements. Purge control valve inlet line to inlet port connection must be blocked. Correct electrical and pneumatic operation of control valves must be verified.
		(1) Purge control valve diaphragm leakage with helium control valve energized.	Maximum allowable leakage is 3 scim.	
		(2) Fast-shutdown valve seat leakage with helium, ignition-phase, and mainstage control valves energized.	Maximum allowable leakage is 10 scim.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.43 (cont)		d. Purge Control Valve Leakage Measurements. Measure the following leakages with helium and mainstage control valves energized and helium tank pressurized to 225-250 psig:		Purge control valve inlet block must be removed and inlet line correctly reinstalled.
		(1) Purge control valve seat leakage.	Maximum allowable leakage is 10 scim.	Purge control valve seat leakage measurement is not required to meet Engine Contractor minimum requirements. Leakage measurement is made at purge control valve vent line exit or on engines incorporating MD166 change but not incorporating MD301, MD302, MD322, or MD323 change, at purge control valve vent port.
		(2) Purge control valve inlet line flange connection.	Leakage is not allowable.	
		e. Purge Control Valve Function and Purge Line Leak Tests. Actuate purge control valve and leak-test valve outlet flange connection and purge line welds, connections, joints, and seals with helium control valve energized, mainstage control valve deenergized, and helium tank pressurized to 225-250 psig.	Purge control valve actuation (purge flow on) must be verified. Leakage is not allowable.	
		f. Determine if flange joint downstream of GG oxidizer purge check valve was disconnected for this test. If disconnected, inspect 4 bolts for proper length after reconnection.	A minimum of one full thread must protrude beyond top of nut.	
		g. Record leakage measurements in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.44	<u>PNEUMATIC CONTROL SYSTEM TEST FOR ENGINE CHECKOUT AT KSC</u>			Successful completion of helium usage test and helium supply system pressure-decay test waives requirement to leak-test the pneumatic control system. Except on restart or anticipated high-helium-usage mission engines, helium fill customer-connect flange and helium fill line must be leak tested. On engines incorporating MD366 or MD371 change, the MRCV actuator piston seal leakage measurement test must be performed. Leakage measurements must be recorded for entry in Engine Log Book.
		a. <u>Pneumatic Control System Separable Joint Leak Tests.</u> Leak-test separable joints pressurized when the following control valves are energized and helium tank is pressurized to 600-1,600 psig:		Purge control valve inlet line to inlet port connection must be blocked. Correct electrical and pneumatic operation of control valves must be verified.
		(1) Helium control valve energized.	Leakage is not allowable.	
		(2) Helium and ignition-phase control valves energized.	Leakage is not allowable.	
		(3) Helium, ignition-phase, and STDV control valves energized.	Leakage is not allowable.	Start tank pressure must be zero before STDV control valve is energized.
		(4) Helium, ignition-phase, and mainstage control valve energized.	Leakage is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.44 (cont)		b. Fast-Shutdown Valve Diaphragm Leakage Measurement.		Fast-shutdown valve diaphragm leakage measurement is not required to meet Engine Contractor minimum requirements. Purge control valve inlet line to inlet port connection must be blocked. Correct electrical and pneumatic operation of control valves must be verified. Leakage measurement must be made at vent port located on end of fast-shutdown valve opposite control port.
		(1) Energize helium control valve, pressurize helium tank to 600-1,600 psig, and measure leakage at fast-shutdown valve vent port.	Maximum allowable leakage is 3 scim.	If leakage exceeds limit, substep 2 is required.
		(2) Remove vent port check valve from GG control valve adjustment plate, energize helium and mainstage control valves, pressurize helium tank to 600-1,600 psig, and measure leakage at fast-shutdown valve vent port.	Maximum allowable leakage is 3 scim.	
		c. Pneumatic Control System Leakage Measurements. Measure the following leakages with applicable control		Pneumatic control system leakage measurements are not required to meet Engine Contractor minimum requirements.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.44 (cont)		valves energized and helium tank pressurized to 600-1,600 psig:		Purge control valve inlet line to inlet port connection must be blocked. Correct electrical and pneumatic operation of control valves must be verified.
		(1) Purge control valve diaphragm leakage with helium control valve energized.	Maximum allowable leakage is 3 scim.	
		(2) Fast-shutdown valve seat leakage with helium, ignition-phase, mainstage control valves energized.	Maximum allowable leakage is 10 scim.	Leakage measurement must be made at vent port located on end of fast-shutdown valve opposite control port.
		d. <u>Purge Control Valve Leakage Measurements.</u> Measure the following leakages with helium and mainstage control valves energized and helium tank pressurized to 600-1,600 psig:		Purge control valve inlet block must be removed and inlet line correctly reinstalled.
		(1) Purge control valve seat leakage.	Maximum allowable leakage is 10 scim.	Purge control valve seat leakage measurement is not required to meet Engine Contractor minimum requirements. Leakage measurement is made at purge control valve vent line exit or, on engines incorporating MD<u>166</u> change but not incorporating MD<u>301</u>, MD<u>302</u>, MD<u>322</u>, or MD<u>323</u> change, at purge control valve vent port.
		(2) Purge control valve inlet line flange connection.	Leakage is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.44 (cont)		e. Purge Control Valve Function and Purge Line Leak Tests. Actuate purge control valve and leak test valve outlet flange connection and purge line welds, connections, joints, and seals with helium control valve energized, mainstage control valve deenergized, and helium tank pressurized to 600-1,600 psig.	Purge control valve actuation (purge flow on) must be verified. Leakage is not allowable.	
		eA. On Engines Incorporating MD366 or MD371 Change, MRCV Actuator Piston Seal Leakage Measurement. Measure leakage at MRCV vent port with helium control valve, mainstage control valve and MRCV low EMR command energized and with helium tank pressurized to 600-1,600 psig.	Maximum allowable leakage is 20 scim.	If purge control valve inlet port is blocked, mainstage control valve does not have to be energized.
		f. Determine if flange joint downstream of GG oxidizer purge check valve was disconnected for this test. If disconnected, inspect 4 bolts for proper length after reconnection.	A minimum of one full thread must protrude beyond top of nut.	
		g. Record leakage measurements in Engine Log Book.		
1.3.45	HELIUM SUPPLY SYSTEM LEAK TEST			Successful completion of helium usage test and helium supply system pressure-decay test waives requirement to leak-test pneumatic system and to measure helium fill-check valve reverse leakage. On restart or anticipated high-helium usage mission engines, helium tank fill customer-connect flange and helium fill line must be leak tested.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.45 (cont)		a. <u>Helium Supply System High-Pressure Leak Test.</u> Leak-test helium system connections, joints, and line welds from customer connect to check valve, tank, helium regulator, inlet, and instrumentation packages, and static-test transducers (on engines not incorporating <u>MD150</u>, <u>MD280</u>, or <u>MD281</u> change) with helium tank pressurized to 1,400-1,600 psig.	Leakage is not allowable.	Control valves must be in deenergized condition.
		b. <u>Helium Fill-Check Valve Reverse-Leakage Measurement.</u> Pressurize helium tank initially to 1,400-1,600 and measure reverse leakage of fill-check valve with helium fill line depressurized to isolate tank pressure.	Maximum allowable leakage is 3 scim.	
		c. Record leakage measurement in Engine Log Book.		
1.3.46	<u>HELIUM TANK EMERGENCY VENT CONTROL VALVE TEST</u>	Actuate emergency vent valve with helium tank pressurized to 100 psig minimum.	Helium tank pressure must vent.	The helium tank emergency vent control valve must be function tested at launch pad prior to pressurizing helium tank to system operating pressure.
1.3.47	<u>HELIUM SUPPLY SYSTEM MASS-LOSS TEST</u>	Pressurize helium tank initially to 1,500 (+100, -0) psig and determine mass-loss rate.	Maximum allowable mass-loss rate is 0.036 lb/hr.	Gas temperature in tank must be stabilized and helium fill line depressurized at start of test period. If calculation results in an apparent mass-gain rate up to 0.005 lb/hr maximum, mass-loss rate must be recorded as zero. If apparent mass-gain exceeds 0.005 lb/hr, repeat test.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.48	HELIUM SUPPLY SYSTEM PRESSURE-DECAY TEST	a. Pressurize helium tank initially to 1,400 (+100, -0) psig and determine pressure-decay rate.	Maximum allowable pressure-decay rate is 90 psi per hour.	A one-hour minimum stabilization period is required before start of test period, and fill line must be depressurized at start of test period.
		b. Record pressure-decay rate in Engine Log Book.		
1.3.48A	HELIUM SUPPLY SYSTEM PRESSURE-DECAY TEST DURING CDDT AND LAUNCH COUNTDOWN FOR SIVB STAGE ENGINES	a. Pressurize helium tank initially to 2,800-3,450 psig. Monitor temperature and pressure for minimum of one hour and determine pressure-decay rate.	$\frac{P_1}{T_1} - \frac{P_2}{T_2} \leq 0.34$ where pressures are in psia and temperatures are in degrees Rankine.	Fill line must be vented to a level below engine helium tank pressure that will provide positive system isolation.
		b. Record test results in Engine Log Book.		
1.3.48B	HELIUM SUPPLY SYSTEM PRESSURE-DECAY TEST DURING CDDT AND LAUNCH COUNTDOWN FOR SII STAGE ENGINES	a. Pressurize helium tank initially to 3,075 ±275 psig. Vent umbilical supply line. Monitor pressure for 15 minutes.		
		b. Multiply pressure loss (psig) by 4 to obtain rate per hour.	Decay rate must not exceed 400 psi per hour.	
		c. Record test results in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.49	<u>GAS GENERATOR AND EXHAUST SYSTEM TEST</u>	Rotate fuel turbine wheel counter-clockwise (as viewed from engine aft end) for 5 rotations minimum, pressurize exhaust system to 30 ±1 psig, and perform the following leak tests and measurements:		The fuel turbine is rotated to seat the turbine seal. The turbine seal must not be rejected for excessive leakage without this rotation. Torque in excess of 1,000 inch-pounds must not be applied to turbine shaft. Exhaust system test plates must be installed. System pressure must not exceed 35 psig. On engines incorporating MD<u>234</u> change, STDV drain port to drain line connection must be blocked until STDV drain leak test. Leakage measurements must be recorded for entry in Engine Log Book.
		a. <u>Oxidizer Turbine Seal Leakage Measurement.</u>	Maximum allowable leakage is 350 scim.	
		b. <u>Fuel Turbine Seal Leakage Measurement.</u>	Maximum allowable leakage is 10,000 scim but must not exceed leakage recorded in Engine Log Book by more than 6,000 scim.	Leakage recorded in Engine Log Book is from final-acceptance checkout (form DD250 signoff) or from initial leak test after turbine seal replacement.
		c. <u>GG Fuel Purge Check Valve Reverse-Leakage Measurement</u>	Maximum allowable leakage is 100 scim.	
		d. <u>Connection, Seal, and Instrumentation/Purge Port and Line Weld Leak Tests (Not in Hot-Gas System).</u> Leak-test STDV hose to STDV connection, and valve flanges and instrumentation/purge ports and lines for GG injector.	Leakage is not allowable.	Leak tests of step d are not required to meet Engine Contractor minimum requirements.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.49 (cont)		e. Connection, Seal, and Instrumentation Port and Line Weld Leak Test (Hot-Gas System):		Flowmeter must be connected to test port for a minimum of 10 seconds before measurement is made.
		(1) Instrumentation ports.	Maximum allowable leakage is 0.3 scim.	
		(2) Instrumentation line welds and connections to FI packages and dummy or static-test transducers (on engines not incorporating MD150, MD280 or MD281 change):	Leakage is not allowable.	
		(3) Metal-plated seals at the following connections:	Maximum allowable leakages are:	
		(a) Fuel turbine exhaust duct connection to oxidizer turbine inlet.	3 scim	
		(b) Oxidizer turbopump connection to heat exchanger.	3 scim	
		(c) Fuel turbopump connection to turbine exhaust duct.	3 scim	
		(d) Oxidizer turbopump torque-access cover plate.	One scim	
		(e) Oxidizer turbopump accessory drive-pad connection to turbine exhaust duct.	One scim	
		(f) Oxidizer turbopump accessory drive pad access plug.	One scim	
		(g) Fuel turbine inlet manifold connection to STDV hose.	One scim	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.49 (cont)		(g) Fuel turbine inlet manifold connection to STDV hose.	One scim	
		f. STDV Drain Line Flange Connection Leak Test (on Engines Incorporating MD234 Change)	Leakage is not allowable.	STDV drain line must be reconnected to drain port.
		g. Record leakage measurements in Engine Log Book.		
1.3.50	THRUST CHAMBER TEST FOR UNINSTALLED ENGINES	Perform the following leak tests and measurements with thrust chamber pressurized to 30 ±5 psig: psig:		Thrust chamber throat plug is required for this test. System pressure must not exceed 35 psig. On restart engines, start tank pressure must be reduced to zero at conclusion of this test.
		a. Connection, Flange Joint, and In-Place Tube Weld Leak Tests.	Leakage is not allowable.	
		b. Oxidizer Injector Purge Check Valve Reverse-Leakage Measurement	Maximum allowable leakage is 80 scim.	
		c. Fuel Jacket Purge Check Valve Reverse-Leakage Measurement	Maximum allowable leakage is 100 scim.	
1.3.51	THRUST CHAMBER TEST DURING ENGINE POST-MANUFACTURING CHECKOUT	a. HYDROGEN TANK PRESSURIZATION Customer-Connect Leak Test. Pressurize thrust chamber 30 ±5 psig.	Leakage is not allowable.	The thrust chamber throat plug is required for this test. Stage fuel tank pressurization system must be isolated from engine (not applicable to SII-stage center engines). System pressure must not exceed 35 psig.
		b. THRUST CHAMBER JACKET PURGE Customer-Connect Leak Test. Pressurize fuel jacket purge line to 30 ±5 psig.	Leakage is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.51 (cont)				On restart engines, start tank pressure must be reduced to zero at conclusion of this test.
1.3.52	<u>THRUST CHAMBER TEST FOR ENGINE CHECKOUT AT MTF, SAC/MDAC, AND KSC</u>	Perform the following leak tests and leakage measurements with thrust chamber pressurized to 30 ±5 psig:		Thrust chamber throat plug is required for this test. Stage fuel tank pressurization system must be isolated from engine (not applicable to SII-stage center engines). System pressure must not exceed 35 psig. On restart engines, start tank pressure must be reduced to zero at the conclusion of this test.
		a. <u>Connection, Flange Joint, and In-Place Tube Weld Leak Tests.</u>	Leakage is not allowable.	Step a is not required at KSC to meet Engine Contractor minimum requirements.
		b. <u>Oxidizer Injector Purge Check Valve Reverse-Leakage Measurement.</u>	Maximum allowable leakage is 80 scim.	
		c. <u>Fuel Jacket Purge Check Valve Reverse-Leakage Measurement.</u>	Maximum allowable leakage is 100 scim.	
		d. <u>MOV Drive Shaft Seal Leakage Measurement.</u>	Maximum allowable leakage is 10 scim.	MOV and MFV drive and idler shaft seal leakage measurements (steps d through g) are not required to meet Engine Contractor minimum requirements.
		e. <u>MOV Idler Shaft Seal Leakage Measurement.</u>	Maximum allowable leakage is 10 scim.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.52 (cont)		f. MFV Drive Shaft Seal Leakage Measurement.	Maximum allowable leakage is 10 scim.	
		g. MFV Idler Shaft Seal Leakage Measurement.	Maximum allowable leakage is 10 scim.	
		h. Record leakage measurements in Engine Log Book.		
1.3.53	OXIDIZER TANK PRESSURIZATION SYSTEM LEAK TEST FOR UNINSTALLED ENGINES	Leak-test connections, flange joints, in-place tube welds, and braid in line flex sections with heat exchanger coils pressurized to 30 ±5 psig.	Leakage is not allowable.	
1.3.54	OXIDIZER TANK PRESSURIZATION SYSTEM LEAK TEST DURING ENGINE POST-MANUFACTURING CHECKOUT	Leak-test the following customer connects with heat exchanger coils pressurized to 25-100 psig.		
		a. OXIDIZER TANK PRESSURIZATION customer connect.	Leakage is not allowable.	
		b. HEAT EXCHANGER HELIUM INLET customer connect on SIVB-stage engines.	Leakage is not allowable.	
1.3.55	OXIDIZER TANK PRESSURIZATION SYSTEM LEAK TEST FOR ENGINE CHECKOUT AT MTF, SAC/MDAC, AND KSC	a. At MTF and SAC/MDAC leak-test connections, flange joints, in-place tube welds, and braid in line flex sections with heat exchanger coils pressurized to 25-100 psig.	Leakage is not allowable.	
		b. At KSC leak test separable flange joints with heat exchanger coils pressurized to 25-100 psig.	Leakage is not allowable.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.56	START TANK VENT-AND-RELIEF VALVE DRAIN LEAK TEST FOR UNISTALLED ENGINES	Leak-test flanges and connections in drain line from START TANK VENT & RELIEF VALVE DRAIN customer connect to start tank vent-and-relief valve with drain line pressurized to 28-30 psig.	Leakage is not allowable.	Pressure in start tank vent-and-relief valve vent line must not exceed control line pressure by more than 30 psi.
1.3.57	START TANK VENT-AND-RELIEF VALVE DRAIN LEAK TEST DURING ENGINE POST-MANUFACTURING CHECKOUT	Leak-test START TANK VENT & RELIEF VALVE DRAIN customer connect with drain line pressurized to 25-250 psig.	Leakage is not allowable.	Pressure in start tank vent-and-relief valve vent line must not exceed control line pressure by more than 30 psig.
1.3.58	START TANK VENT-AND-RELIEF VALVE DRAIN LEAK TEST FOR ENGINE CHECK-OUT AT MTF, SAC/MDAC, AND KSC	Leak-test separable connections in drain line from START TANK VENT & RELIEF VALVE DRAIN customer connect to start tank vent-and-relief valve with drain line pressurized to 25-250 psig.	Leakage is not allowable.	Pressure in start tank vent-and-relief valve vent line must not exceed control line pressure by more than 30 psig.
1.3.59	MAINSTAGE OK PRESSURE SWITCH TEST FOR UNISTALLED ENGINES			Electrical safety circuit tests must be made before performing this test.
		a. Calips Checkout Line and Pressure Switch Connection Leak Test. Pressurize CALIPS CHECKOUT LINE customer connect to 225-250 psig.	Leakage is not allowable.	
		b. Mainstage OK Pressure Switch Actuation Test. Perform the following pressurization operations to determine switch actuation and deactuation points:		Pressures required for this test exceed personnel safe-operating limits for test site.
		(1) Cycle pressure switches by pressurizing checkout line to 600 ±25 psig and then depressurizing line to zero.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.59 (cont)		(2) Pressurize checkout line until switch actuates or to 600 psig maximum; perform twice for each switch.	Each mainstage OK pressure switch must actuate at 500 ±30 psig.	
		(3) Depressurize checkout line until switch deactuates; perform twice for each switch.	Each mainstage OK pressure switch must deactuate 20-105 psi below its actuation pressure.	
		c. Record actuation and deactuation in Engine Log Book.		
1.3.60	MAINSTAGE OK PRESSURE SWITCH TEST	a. Mainstage OK Pressure Switch Actuation Test. Perform the following pressurization operations to determine switch actuation and deactuation points:		Pressures required for this test may exceed personnel safe-operating limits for test site.
		(1) Cycle pressure switches by pressurizing checkout line to 600 ±25 psig and then depressurizing line to zero.		
		(2) Pressurize checkout line until switch actuates or to 600 psig maximum; perform twice for each switch.	Each mainstage OK pressure switch must actuate at 500 ±30 psig.	
		(3) Depressurize checkout line until switch deactuates; perform twice for each switch.	Each mainstage OK pressure switch must deactuate 20-105 psi below its actuation pressure.	
		b. Record actuation and deactuation pressures in Engine Log Book.		
1.3.61	MAINSTAGE OK PRESSURE SWITCH PRESSURE-DECAY TEST	a. Leak-test checkout line and pressure switch connections with CALIPS CHECKOUT LINE customer connect pressurized to 90-100 psig.	Leakage is not allowable.	Checkout line and pressure switch connection leak test is not required to meet Engine Contractor minimum requirements.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.61 (cont)		b. Pressurize checkout line initially to 400 ±10 psig and determine pressure-decay rate.	Maximum allowable pressure-decay rate is 10 psi per 15-minute period.	Checkout line and switches must be isolated from pneumatic supply at start of test period. If pressure-decay rate is not within limits, step c is required.
		c. Pressurize checkout line initially to 400 ±10 psig and determine switch No. 1 pressure-decay rate with checkout line to switch No. 2 blocked.	Maximum allowable pressure-decay rate is 10 psi per 15-minute period.	Checkout line and switch No. 1 must be isolated from pneumatic supply at start of test period. If switch No. 1 pressure-decay rate is acceptable, step d must be performed.
		d. Determine switch No. 2 pressure-decay rate by subtracting acceptable rate measured in step c from rate measured in step b.	Maximum allowable pressure-decay rate is 10 psi per 15-minute period.	
		e. Record pressure-decay rates in Engine Log Book.		
1.3.62	<u>ENGINE SEQUENCE TEST FOR UNINSTALLED ENGINES</u>	Verify engine control system operation by performing the following operations with helium tank pressurized to 1,400-1,600 psig:		Electrical safety circuit tests must be made before performing this test. Three sequence test runs are required; last 2 runs must include recording of valve timing, timer operation, and sequence of events. A minimum delay of 5 minutes is required between runs. Start tank pressure must be zero before sequence test begins.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.62 (cont)		a. Energize engine electrical power buses.	Ignition-complete indication must not be obtained.	Mainstage OK bypass and ignition-complete bypass circuits must be energized. Circuit must remain energized for all sequence runs.
		aA. On engines incorporating MD366 or MD371 change, energize MRCV control solenoid.		
		b. Energize fuel injection temperature detector bypass circuit on engines incorporating MD204 change or not incorporating ECA 502670-211.		
		c. Perform the following operations for first sequence run on engines incorporating ECA 502670-211:		
		(1) Make sure fuel injection temperature OK circuit is in off condition prior to engine (sequence) start.		
		(2) Energize fuel injection temperature OK bypass circuit after ignition-complete indication is obtained (while sequence run is delayed).	Fuel injector temperature OK indication must be obtained, and sequence run must resume.	
		(3) Energize fuel injection temperature detector bypass circuit after cutoff of first run and prior to subsequent runs.		Circuit must remain energized for remaining sequence runs.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.62 (cont)		cA. On engines incorporating MD366 or MD371 change, approximately 5 seconds after mainstage condition is obtained, deenergize MRCV control solenoid. Read MRCV potentiometer output voltage.		
		cB. On engines incorporating MD366 or MD371 change, approximately 2 seconds after step cA, energize MRCV control solenoid. Read MRCV potentiometer output voltage.	On engines incorporating MD371 change, voltage change from step cA must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step cA must be between 0.6 and 1.0 vdc.	
		d. Verify correct engine operation using the following recorded measurements from last sequence run:		
		(1) Measure valve operating times.	Valve operating times must be within limits of figure 1-11.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.62 (cont)		(2) Measure the following sequence controller times:	<u>Allowable Timer Operating Times in Seconds</u>	
		(a) Start tank discharge delay (from helium control solenoid signal--engine start--to STDV control solenoid signal).	1.000 ±0.040	
		(b) Ignition phase (from STDV control solenoid signal to mainstage control solenoid signal).	0.450 ±0.030	
		(c) Sparks deenergized (from mainstage control solenoid signal to ASI and GG sparks off signal).	3.30 ±0.200	
		(d) Helium control deenergized (from cutoff signal to helium control solenoid off signal).	1.00 ±0.110	
		(3) Verify sequence of events of the following engine sequence phases:	<u>Sequence of Events</u>	
		(a) Ignition phase.	Helium control valve energized Ignition-phase control valve energized Bleed valves closed ASI and GG sparks on MFV opened ASI valve opened Ignition completed STDV control valve energized STDV opened	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.62 (cont)		(b) Mainstage phase.	Mainstage control valve energized MOV opened GG control valve opened OTBV closed STDV control valve deenergized STDV closed ASI and GG sparks off	
		(c) Cutoff phase.	Ignition-phase control valve deenergized Mainstage control valve deenergized GG control valve closed ASI valve closed MFV closed MOV closed OTBV opened Helium control valve deenergized Bleed valves opened	
		dA. On engines incorporating MD366 or MD371 change, approximately 5 seconds after engine cutoff command, deenergize MRCV control solenoid. Read MRCV potentiometer output voltage.	On engines incorporating MD371 change, voltage change from step cB must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step cB must be between 0.6 and 1.0 vdc.	
		e. Determine OTBV closing time variation.	OTBV closing time in final sequence run must be within 50 milliseconds of closing time in preceding run.	
		f. Record test results in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.63	<u>ENGINE SEQUENCE TEST DURING ENGINE POST-MANUFACTURING CHECKOUT AND ENGINE CHECKOUT AT VAB (KSC)</u>	Verify engine control system operation by performing the following operations with helium tank initially pressurized to 1,400-3,200 psig and maintained at more than 800 psig during sequence runs.		Sequence test must include recording of valve timing, timer operation, and sequence of events. Pneumatic control system must be cycled two complete times prior to running sequence test (within 72 hours) to determine valve timing. When the engine spark exciters are operated during sequence tests, a minimum delay of 5 minutes is required between runs. Engine start tank pressure must be zero, engine propellant inlet duct pressures must not be greater than 5 psig, and stage pre-valves must be closed before initiating engine sequence test. At KSC, on engines incorporating MD211 change or FSDV 558127-11, perform test consisting of a minimum of 12 cycles as near launch date as practical but within 120 days of launch, using continuous, noncommutated (hardwire) system for recording. Record at least 6 cycles starting with third cycle. If the 120 day requirement is exceeded and it has been less than 6 months since the last 12 cycle sequence test was run, a 3 cycle sequence test is sufficient to reverify the system. If it has been more than 6 months since the last 12 cycle sequence test, the entire 12 cycles must be repeated.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.63 (cont)				At KSC, on engines not incorporating MD211 change or FSDV 558127-II, cycle pneumatic control system two complete times; then perform and record a single engine sequence test.
		a. Measure MOV housing temperature, and determine correction factor for use in adjusting recorded MOV opening time measurement to corrected value.		On SII-stage engines, if all 5 MOV temperatures cannot be measured, at least one outboard and the center engine MOV temperatures must be measured.
		b. Energize engine electrical power buses.	Ignition-complete indication must be obtained on engines incorporating MD338 change.	Engine voltages must be within requirements listed in section II. On engines incorporating MD338 change, when ignition-complete indication is obtained, ignition detection simulation circuit must not be energized.
		c. Energize ignition detection simulation circuit on engines not incorporating MD338 change.	Ignition-complete indication must be obtained.	
		d. Energize mainstage enable circuit on SIVB-stage engines.		
		dA. On engines incorporating MD366 or MD371 change, energize MRCV low EMR command.		
		e. Energize mainstage OK bypass circuit after engine (sequence) start at the following point during run: after mainstage control solenoid signal and before sparks deenergized timer expiration.	Mainstage OK No. 1 and No. 2 indications must be obtained, and engine sequence run must continue into mainstage phase.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.63 (cont)		eA. On engines incorporating MD366 or MD371 change, approximately 5 seconds after mainstage condition is obtained, deenergize MRCV low EMR command. Read MRCV potentiometer output voltage.		
		eB. On engines incorporating MD366 or MD371 change, approximately 2 seconds after step eA, energize MRCV low EMR command. Read MRCV potentiometer output voltage.	On engines incorporating MD371 change, voltage change from step eA must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step eA must be between 0.6 and 1.0 vdc.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.63 (cont)		f. Verify engine-ready indication in correct sequence after engine (sequence) cutoff.	Engine-ready indication must be obtained after OTBV open indication.	
		fA. On engines incorporating MD366 or MD371 change, approximately 5 seconds after engine cutoff command, de-energize MRCV low EMR command. Read MRCV potentiometer output voltage.	On engines incorporating MD371 change, voltage change from step eB must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step eB must be between 0.6 and 1.0 vdc.	
		g. Verify correct engine operation using the following measurements from last sequence run:		
		(1) Measure valve operating times.	Valve operating times must be within limits of figure 1-11.	On engines incorporating MD265 change, MOV opening time is allowed to vary within a band of 50 milliseconds between sequence test if average time falls within limits of figure 1-11. All times obtained since installation of control orifice must be used to obtain average time.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.63 (cont)		(2) Measure the following sequence controller times:	Allowable Timer Operating Times in Seconds	
		(a) Start tank discharge delay (from helium control solenoid signal--engine start--to STDV control solenoid signal)	1.000 ±0.040	
		(b) Ignition phase (from STDV control solenoid signal to mainstage control solenoid signal)	0.450 ±0.030	
		(c) Sparks deenergized (from mainstage control solenoid signal to ASI and GG sparks off signal)	3.30 ±0.200	
		(d) Helium control deenergized (from cutoff signal to helium control solenoid off signal)	1.00 ±0.110	
		(3) Verify sequence of events of the following engine sequence phases:	Sequence of Events	
		(a) Ignition phase	Helium control valve energized Ignition-phase control valve energized Bleed valves closed ASI and GG sparks on MFV opened ASI valve opened Ignition completed STDV control valve energized STDV opened MRCV opened	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.63 (cont)			Sequence of Events	
		(b) Mainstage phase.	Mainstage control valve energized	
			MOV opened	
			GG control valve opened	
			OTBV closed	
			STDV control valve de-energized	
			STDV closed	
			ASI and GG sparks off	
			MRCV closed/opened	
		(c) Cutoff phase.	Ignition-phase control valve deenergized	
			Mainstage control valve de-energized	
			GG control valve closed	
			ASI valve closed	
			MFV closed	
			MOV closed	
			OTBV opened	
			Helium control valve deenergized	
			Bleed valves opened	
			MRCV closed	
		h. Determine spark rate and spark system operating time.	Spark rate must be within requirements listed in section II. The 4 spark igniters must be energized from approximately 0.5 second after engine start until 3.3 ±0.200 seconds after mainstage control valve solenoid is energized.	
		i. Record test results in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.64	<u>ENGINE SEQUENCE TEST DURING CDDT AND LAUNCH PREPARATION</u>	Verify engine control system operation by performing the following operations with helium tank initially pressurized to 1,400-3,200 psig and maintained at more than 800 psig during sequence runs:		This test must be performed during launch countdown (with the objective of maintaining a 72-hour maximum interval to launch) to verify, within limitations of stage telemetry system, proper operation of engine electrical and mechanical functions. Sequence test must include recording of valve and timer operations and sequence of events. Hardwire recording of spark traces is required to verify timer operation. Pneumatic control system must be cycled two complete times before running sequence test to determine valve timing. A minimum delay of 5 minutes is required between runs. Engine start tank pressure must be zero, engine propellant inlet duct pressures must not be greater than 5 psig, and stage pre-valves must be closed before initiating engine sequence test.
		a. Energize engine electrical power buses.	Ignition-complete indication must be obtained.	Engine voltages must be within limits listed in section II. When ignition-complete indication is obtained, ignition detection simulation circuit must not be energized.
		b. Energize mainstage enable circuit on SIVB-stage engines.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.64 (cont)		bA. On engines incorporating MD366 or MD371 change, energize MRCV low EMR command.		
		c. Energize mainstage OK bypass circuit after engine (sequence) start at the following point during run: after mainstage control solenoid signal and before sparks deenergized timer expansion.	Mainstage OK No. 1 and No. 2 indications must be obtained, and engine sequence run must continue into mainstage phase.	
		cA. On engines incorporating MD366 or MD371 change, approximately 5 seconds after mainstage condition is obtained, deenergize MRCV low EMR command. Read MRCV potentiometer output voltage.		
		cB. On engines incorporating MD366 or MD371 change, approximately 2 seconds after step cA, energize MRCV low EMR command. Read MRCV potentiometer output voltage.	On engines incorporating MD371 change, voltage change from step cA must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step cA must be between 0.6 and 1.0 vdc.	
		d. Verify engine-ready indication in correct sequence after engine (sequence) cutoff.	Engine-ready indication must be obtained after OTBV open indication.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.64 (cont)		dA. On engines incorporating MD366 or MD371 change, approximately 5 seconds after engine cutoff command, deenergize MRCV low EMR command.	On engines incorporating MD371 change, voltage change from step cB must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step cB must be between 0.6 and 1.0 vdc.	
		e. Verify correct engine operation and sequence of event of the following engine sequence phases:	Sequence of Events	
		(1) Ignition phase.	Helium control valve energized Ignition-phase control valve energized Bleed valves closed ASI and GG sparks on MFV opened ASI valve opened Ignition completed STDV control valve energized STDV opened MRCV opened	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.64 (cont)			<u>Sequence of Events</u>	
		(2) Mainstage phase.	Mainstage control valve energized	
			MOV opened	
			GG control valve opened	
			OTBV closed	
			STDV control valve de-energized	
			STDV closed	
			ASI and GG sparks off	
			MRCV closed/opened	
		(3) Cutoff phase.	Ignition-phase control valve deenergized	
			Mainstage control valve de-energized	
			GG control valve closed	
			ASI valve closed	
			MFV closed	
			MOV closed	
			OTBV opened	
			Helium control valve de-energized	
			Bleed valves opened	
			MRCV closed	
		f. Record test results in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.65	ENGINE PNEUMATIC SYSTEM HELIUM USAGE TEST	Determine pneumatic system helium usage in accordance with the requirements in paragraphs 1.3.65.1 and 1.3.65.2.		Paragraphs 1.3.65.1 and 1.3.65.2 contain independent requirements; paragraph 1.3.65.2 may be performed before paragraph 1.3.65.1.
1.3.65.1	Engine Pneumatic System Helium Usage Sequence Test	Determine pneumatic system (sequence) helium usage by performing the following operations with helium tank initially pressurized to 1,400-3,200 psig:		Engine start tank pressure must be zero, engine propellant inlet duct pressures must not be greater than 5 psig, and stage prevalves must be closed before initiating helium usage sequence test. Helium tank gas pressure and temperature must be monitored. Tank gas temperature must be stabilized to a rate of change equal to or less than one degree per minute before test begins. Helium fill line must be depressurized to isolate helium tank gas after temperature stabilization is achieved and before test begins.
		a. Measure and record helium tank pressure just before engine (sequence) start.	Pressure must be 1,400-3,200 psig.	
		b. Perform engine sequence test in accordance with the following requirements:		
		(1) Energize engine electrical power buses.	Ignition-complete indication must be obtained on engines incorporating MD338 change.	Engine voltages must be within limits listed in section II.
		(1A) On engines incorporating MD366 or MD371 change, energize MRCV low EMR command.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.65.1 (cont)				On engines incorporating MD338 change, when ignition-complete indication is obtained, ignition detection simulation circuit must not be energized.
		(2) Energize ignition detection simulation circuit on engines not incorporating MD338 change.	Ignition-complete indication must be obtained.	
		(3) Energize mainstage enable circuit on SIVB-stage engines.		
		(4) Energize mainstage OK bypass circuit after engine (sequence) start at the following point curing run: after mainstage control solenoid signal and before sparks deenergized timer expiration.	Mainstage OK No. 1 and No. 2 indications must be obtained and engine sequence run must continue into mainstage phase.	
		(5) On engines incorporating MD371 change, approximately 5 seconds after mainstage condition is obtained, deenergize MRCV low EMR command.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.65.1 (cont)		NOTE When cycling the MRCV in substep 6 or 7, use time that will duplicate the activity that will be required of the MRCV during flight. On restart mission engines, use time that will be required of the MRCV during second burn. If flight time (mission) is not known, use times specified in substep 6 or 7.		
		(6) On engines incorporating MD371 change, approximately 320 seconds after mainstage condition is obtained, energize MRCV low EMR command.		
		(7) On engines incorporating MD366 change, approximately 115 seconds after mainstage condition is obtained, deenergize MRCV low EMR command.		
		(8) Energize engine (sequence) cutoff circuit (if not sequenced automatically) 360 ±30 seconds after beginning of mainstage phase.	Engine (sequence) cutoff must occur, and engine-ready indication must be obtained after OTBV open indication.	
		(9) On engines incorporating MD371 change, approximately 5 seconds after engine cutoff command, deenergize MRCV low EMR command.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.65.1 (cont)		c. Determine helium usage as follows: (1) If sequence test duration was 360 ±4 seconds, measure and record helium tank pressure approximately one second after engine cutoff signal. Calculate difference in pressure as measured in step a to determine helium usage. (2) If sequence test duration varied by more than 4 seconds from 360 seconds, calculate pressure decay as follows: $\text{Pressure decay} = \Delta P_1 + \frac{360 \ \Delta P_2}{t} + \Delta P_3$ where ΔP_1 = pressure drop from engine start to engine start plus 2 seconds (psi) ΔP_2 = pressure drop from engine start plus 2 seconds to engine cutoff (psi) ΔP_3 = pressure drop from engine cutoff plus one second (psi) t = time from engine start to engine cutoff (seconds) must be 360 ±30 seconds) d. Record results of helium usage test in Engine Log Book.	Maximum allowable pressure difference (ΔP) is determined from the equation $\Delta P = 0.12P + 870 + A$ where ΔP = maximum allowable pressure difference in psi P = initial tank pressure (1,400-3,200 psig) A = value for adjusting maximum calculated pressure difference for oxidizer turbopump intermediate seal purge flow. (Add 9 psi for each 100 scim of purge flow in excess of 4,400 scim, or subtract 9 psi for each 100 scim of purge flow less than 4,400 scim.)	Values of ΔP are based on one-second fuel lead, mainstage-phase duration of 360 seconds, tank gas temperature stabilization at rate of change equal to or less than one degree per minute, and helium usage from engine start signal to cutoff signal plus one second. The oxidizer turbopump intermediate seal purge flow value used to calculate maximum allowable ΔP must be based on the last flow measurement with the helium tank pressurized to at least 575 psig. If pressure remaining in helium tank at completion of helium usage test is less than 450 psig and initial helium tank pressure was less than 1,750 psig, initial helium tank pressure must be increased to a minimum of 1,750 psig and test repeated.
1.3.65.2	Pneumatic Accumulator System Test	Determine pneumatic accumulator system helium usage by performing the following operations: a. Measure and record pneumatic system pressure at boss in MFV closing control		MD333 change must be incorporated before this test is performed. Propellant inlet duct pressures must be zero before this test is performed. Because this test may exceed personnel safety limits, MFV closing line boss monitor gage (equipped with vent

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Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.65.2 (cont)		line with helium and main-stage control valves energized and helium tank pressurized to 600-3,200 psig.		valve) must be positioned at a safe distance from engine in accordance with site safety standards.
				Line length from engine boss to pressure monitor must not exceed 30 feet for 1/4-inch line.
				Pressure measured on gage must be converted to absolute pressure.
		b. Measure and record system pressure at MFV line boss after performing the following operations in immediate succession:		Pressure measured on gage must be converted to absolute pressure.
		(1) Energize ignition-phase control valve.		
		(2) Deenergize helium control valve.		
		(3) Deenergize ignition-phase control valve.		
		c. Energize helium and ignition-phase control valves.		
		d. Measure and record system pressure at MFV line boss after performing the following operations:		Pressure measured on gage must be converted to absolute pressure.
		(1) Deenergize helium control valve.		
		(2) Wait 6 minutes (+5, -0 seconds).		
		(3) Deenergize ignition-phase control valve.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.65.2 (cont)		e. Determine final accumulator system pressure using the following equation: Final accumulator pressure = $P3 \times \frac{P1}{P2}$ where P1 is absolute pressure calculated in step a P2 is absolute pressure calculated in step b P3 is absolute pressure calculated in step d	Minimum allowable final accumulator pressure is 315 psia.	
		f. Record final accumulator system pressure in Engine Log Book.		
1.3.66	<u>OXIDIZER AND FUEL INLET DUCTS TORSIONAL BELLOWS LEAK TEST</u>			This test must be performed at test sites after completing drying of paragraph 1.5.30 and once at KSC during launch preparation before CDDT. During this test a Uson 500 helium leak detector (or equivalent) may be used for preliminary leak detection but a mass-spectrometer must be used for inlet duct rejection.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.3.66 (cont)				Inlet duct torsional bellows protective covers must be removed only as necessary to perform leak test and must be correctly reinstalled as soon as leak test is completed.
		a. Bag inlet duct center flange with plastic film. Seal bag to flange with pressure-sensitive tape.		Drain holes on downstream side of flange must be sealed. Do not remove tape from drain holes at completion of test.
		b. Pressurize inlet duct to normal stage propellant tank pressure capability.		Pressure used for this test must be between 10 and 35 psig.
		c. Insert probe of detection device into plastic bag and search flange joint for leakage.	Zero indicated leakage with mass-spectrometer set for leak evaluation of 1 x 10^{-4} cc helium per second.	Entire circumference of flange must be searched for leakage. If leakage exceeds limit, steps d through f are required.
		d. Place a second bag of plastic film over existing bag and seal with pressure-sensitive tape.		
		e. Clear any helium vapors from between bags by purging with gaseous nitrogen.		Maintain gaseous nitrogen purge of area between bags until just before rechecking flange area for leakage.
		f. Repeat search of flange joint area for leakage.	Zero indicated leakage with mass-spectrometer set for leak evaluation of 1 x 10^{-4} cc helium per second.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.4	STORAGE AND SHIPMENT PREPARATION			
1.4.1	ENGINE STORAGE PREPARATION FOR UNINSTALLED ENGINES	a. Visually inspect overall engine for damage or corrosion.	Damage or corrosion is not allowable.	Engine must be stored on Engine Handler G4064 when possible but may be stored vertically if necessary. Engine must be stored in accordance with environmental requirements in section II and/or MSFC-STD-496 or MSFC-STD-498. When engine is stored in accordance with MSFC-STD-496 or MSFC-STD-498, engine protective covers must be removed (paragraph 1.C.13). Any activity on a stored engine for other than storage maintenance purposes requires reinstallation of protective covers (paragraph 1.6.19).
		aA. Measure pressure in ECA and primary and auxiliary FI packages.	Pressure must be within limits specified in paragraph 1.3.1.	
		aB. Measure pressure in spark igniter cables.	Pressure must be within limits specified in paragraph 1.3.2.	
		b. Visually inspect engine covers and closures for:		
		(1) Damage.	Damaged covers and closures are not allowable.	
		(2) Installation.	Improperly installed or missing covers and closures are not allowable.	
		c. Install desiccant in engine closures in accordance with desiccant installation requirements outlined in section II.		Correct quantity of desiccant as specified on closure must be installed. The humidity indicators on engine closures must indicate an acceptable condition for at least 24 hours before storing engine (refer to paragraph 1.1.18).

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.4.1 (cont)		d. If engine is installed on handler, install 640 units of activated desiccant in engine handler and install engine cover assembly.		
1.4.2	ENGINE STORAGE PREPARATION FOR STAGE-INSTALLED ENGINES	a. Visually inspect overall engine for damage or corrosion.	Damage or corrosion is not allowable.	Engine must be stored in accordance with environmental requirements in section II and/or MSFC-STD-496 or MSFC-STD-498. When engine is stored in accordance with MSFC-STD-496 or MSFC-STD-498, engine protective covers must be removed (paragraph 1.6.13). Any activity on a stored engine for other than storage maintenance purposes requires reinstallation of protective covers (paragraph 1.6.19).
		aA. Measure pressure in ECA and primary and auxiliary FI packages.	Pressure must be within limits specified in paragraph 1.3.1.	
		aB. Measure pressure in spark igniter cables.	Pressure must be within limits specified in paragraph 1.3.2.	
		b. Visually inspect engine covers and closures for:		
		(1) Damage.	Damaged covers and closures are not allowable.	
		(2) Installation.	Improperly installed or missing covers and closures are not allowable.	
		c. Install desiccant in engine closures in accordance with desiccant installation requirements outlined in section II.		Correct quantity of desiccant as specified on closures must be installed. The humidity indicators on engine closures must indicate an acceptable condition for at least 24 hours before storing engine (refer to paragraph 1.1.17).

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.4.2 (cont)		d. Secure engine in null position with mechanical gimbal actuator locks.		
1.4.3	<u>ENGINE SHIPMENT PREPARATION FOR UNINSTALLED ENGINES</u>			Engine must be installed on Engine Handler G4064 for shipment. During shipment, engine temperature must remain within -20° to +140° F.
		a. Visually inspect engine covers and closures for:		
		(1) Damage.	Damaged covers and closures are not allowable.	
		(2) Installation.	Improperly installed or missing covers and closures are not allowable.	Correct quantity of desiccant must be installed, and applicable closures must be marked to indicate desiccant installation.
		Inspect engine humidity indicators for evidence of excessive moisture.	Relative humidity must be less than 30 percent (30 and 40 indicators blue).	During shipment, engine humidity must remain less than 30 percent. Humidity requirements for desiccant and engine covers and closures are detailed in section II.
		c. Install engine cover on engine after engine is installed on handler, and install quantity of desiccant under cover as necessary to maintain humidity requirement.	Relative humidity must be less than 30 percent.	During shipment humidity under security cover must remain less than 30 percent.
		d. Make sure all applicable engine records are shipped with engine.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.4.4	ENGINE SHIPMENT PREPARATION FOR STAGE-INSTALLED ENGINES			During shipment, engine temperature must remain within -20° to +140° F.
		a. Visually inspect engine covers and closures for:		
		(1) Damage.	Damaged covers and closures are not allowable.	
		(2) Installation.	Improperly installed or missing covers and closures are not allowable.	Correct quantity of desiccant must be installed, and applicable closures must be marked to indicate desiccant installation.
		b. Inspect engine humidity indicators for evidence of excessive moisture.	Relative humidity must be less than 30 percent (30 and 40 indicators blue).	During shipment, engine humidity must remain less than 30 percent. Humidity requirements for desiccant and engine covers and closures are detailed in section II.
		c. Inspect thrust chamber insulation for damage.	Damage is not allowable.	
		d. Inspect engine component serial numbers for agreement with Engine Log Book.	Numbers on serialized components must agree with serial numbers recorded in Engine Log Book.	Applicable to components with visible external serial numbers.
		e. Secure engine in null position with mechanical gimbal actuator locks.		
		f. Make sure all applicable engine records are shipped with stage.		
		g. Enter inspection information in Engine Log Book.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5	SERVICING			
1.5.1 (Deleted)				
1.5.2	PROPELLANT LOADING PREPARATION FOR COUNTDOWN DEMONSTRATION TEST AND LAUNCH PREPARATION	Initiate engine system purge sequence for pre-propellant loading and propellant loading operations.		Purges must meet requirements in section II for flight (SII-stage and SIVB-stage engines). Special purge requirements for engine temperature at or below 35° F are in section II.
1.5.3	THRUST CHAMBER CONDITIONING (PRE-CHILL)	Initiate thrust chamber jacket purge for thrust chamber conditioning.		Purge must meet requirements in section II for static-testing of stages and for flight as applicable. Engine temperature must meet requirements in section II for thrust chamber pre-chill.
1.5.4	HELIUM TANK CONDITIONING	Fill helium tank to pressure and at temperature sufficient to achieve conditioning.		Helium tank gas pressure and temperature must meet conditioning requirements in section II. Helium tank must be filled before start tank is filled. If helium tank pressure exceeds 3,450 psia, reduce pressure using helium emergency vent control valve. On engines not incorporating MD333 change, after completion of engine checkout during countdown demonstration test securing, helium supply system pressure-decay test must be repeated if helium tank emergency vent control valve is actuated.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.5	START TANK PURGING	Perform start tank purging before filling and conditioning start tank.		Purge must meet requirements in section II.
1.5.6	START TANK PURGING AFTER LAUNCH COUNTDOWN ABORT	Perform start tank purging after tank is depressurized, using helium at 500 psia maximum and at ambient temperature.	Purging must be continued for 10 minutes minimum.	
1.5.7	START TANK CONDITIONING	Fill start tank to pressure and at temperature sufficient to achieve conditioning.		Start tank gas pressure and temperature must meet conditioning requirements in section II. Helium tank must be filled before start tank is filled. If start tank pressure exceeds 1,400 psia, reduce pressure by actuating start tank vent-and-relief valve; if vent-and-relief valve does not vent tank, start tank emergency vent valve must be actuated.
1.5.8	START TANK DEPRESSURIZATION	Depressurize start tank by actuating start tank vent-and-relief valve.	Start tank must depressurize.	
1.5.9	HELIUM TANK DEPRESSURIZATION	Depressurize helium tank by energizing helium control valve and bleeding pressure through pneumatic control system.	Helium tank must depressurize.	

1.5.10 through 1.5.15 (Deleted)

All data on pages 1-147 and 1-148 deleted.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.13 (cont)			Minimum Purge Duration (Minutes)	
		b. Oxidizer dome (facility line to instrumentation port CO3a).	45	
		c. Thrust chamber jacket (customer-connect line) with helium at low pressure.	45	
1.5.14	<u>ENGINE SYSTEM PURGING (SII STAGE) AFTER STAGE STATIC-TEST ABORT BEFORE ENGINE START</u>	Initiate the following applicable purges if preconditioning is terminated before engine start:		Purges must meet requirements in section II for static testing SII-stage engines (or alternate SII-stage engine requirements).
		a. Thrust chamber jacket (customer-connect line) with helium at 200 psia maximum.	If test is to be recycled, purge must be continued until preconditioning is restarted; if test is to be rescheduled, purge must be continued until there is no evidence of frost or moisture on oxidizer dome.	The purges in step b may be performed instead of step a.
		b. Thrust chamber jacket (customer-connect line) with helium and gaseous nitrogen in the following sequence:		
		(1) Helium purge at 200 psia maximum.	Purge must be supplied for 5 minutes minimum.	Gaseous nitrogen purge must be initiated immediately upon termination of helium purge.
		(2) Gaseous nitrogen purge at 165-215 psia.	If test is to be recycled, purge must be continued until helium (200 psia) purge is restarted before reconditioning; if test is to be rescheduled, purge must be continued until there is no evidence of frost or moisture on oxidizer dome.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.15	ENGINE SYSTEM PURGING (SII STAGE) FOR STAGE STATIC-TEST ABORT AFTER ENGINE START	Perform purging operations in paragraph 1.5.15.1 or 1.5.15.2, as applicable.		
1.5.15.1	Engine System Purging When Facility Line Is Not Supplied for Oxidizer Dome Purge (SII)	a. Initiate thrust chamber jacket purge to remove frost and moisture from main injector hardware.		Suggested purge values are: gaseous nitrogen at 215-265 psia, 100° to 200° F, and flowrate of 130 scfm (reference).
		b. Inspect main injector hardware in accordance with paragraph 1.1.7.	Main injector hardware must be free of frost or moisture before subsequent normal purge operations are resumed.	
1.5.15.2	Engine System Purging When Facility Line Is Supplied for Oxidizer Dome Purge (SII Alternate)	Initiate the following purges if main injector hardware inspection in paragraph 1.1.7 cannot be performed:	Purges must be supplied for the following lengths of time and before subsequent preconditioning: Minimum Purge Duration (Minutes)	Purges must meet requirements in section II for static-testing SII-stage engines (alternate).
		a. Fuel turbopump and GG (purge manifold system).	10	If required purge pressure is not attained at customer connect within 0.2 second of engine cutoff, purge temperature must be increased to 100° to 200°F, and purging continued for 2 hours minimum before starting any subsequent test.
		b. Oxidizer dome (facility line to instrumentation port CO3a).	45	
		c. Thrust chamber jacket (customer-connect line) with gaseous nitrogen at 165-215 psia.	45	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.16	<u>THRUST CHAMBER JACKET PURGING AFTER LAUNCH COUNTDOWN ABORT (SIVB AND SII)</u>	Initiate thrust chamber jacket purge with helium at 200 psia maximum and ambient temperature (80 scfm minimum) if preconditioning is prematurely terminated before launch.	Purge must be supplied for 5 minutes before starting subsequent preconditioning.	Purge must meet requirements in section II for flight (SIVB and SII).
1.5.17	<u>THRUST CHAMBER JACKET DRYING</u>			If thrust chamber jacket drying is to be performed in sequence with fuel or oxidizer system drying, thrust chamber drying must be performed first.
		a. Prepare the following flow paths:		
		(1) Thrust chamber exit open.		Exit closure must be installed so as to partially cover exit.
		(2) Stage fuel tank pressurization line open.		
		b. Initiate either of the following purges through thrust chamber jacket purge line, and measure humidity of gas emerging from thrust chamber exit:	Purge-drying must be performed for a minimum of 5 minutes and until humidity is within limits of figure 1-13.	Purge pressure and temperature values are referenced to customer-connect panel. Air conforming to the requirements of MSFC-PROC-404 is an acceptable alternate drying agent for gaseous nitrogen.
		(1) Helium at 40-60 psig and 50° to 200° F.		
		(2) Gaseous nitrogen at 150-200 psig and 50° to 200° F.		
1.5.18	<u>FUEL SYSTEM DRYING</u>	Perform drying operations in paragraph 1.5.18.1 or 1.5.18.2, as applicable.		If fuel system drying is to be performed in sequence with thrust chamber jacket drying, thrust chamber drying must be performed first.
1.5.18.1	<u>Fuel System Drying for SIVB-Stage Engines</u>	a. Prepare the following flow paths:		
		(1) Stage recirculation valve closed.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.18.1 (cont)		(2) Stage fuel pre-valve closed.		
		(3) Instrumentation port on stage fuel recirculation return line open.		
		b. Dry recirculation system by initiating purge at fuel inlet duct instrumentation port (downstream of pre-valve) with helium or gaseous nitrogen at 25-30 psig in gas supply line and 50° to 200° F (at purge inlet), and measure humidity of gas in stage fuel tank and at fuel recirculation return line instrumentation port.	Purge-drying must be performed for a minimum of 15 minutes and until humidity is within limits of figure 1-13.	
		c. Prepare the following flow paths:		
		(1) Thrust chamber exit open.		Exit closure must be installed so as to partially cover exit.
		(2) Oxidizer turbine seal drain line open.		
		(3) Oxidizer turbopump primary seal drain line open.		
		(4) Oxidizer turbopump intermediate seal purge check valve vent line open.		
		(5) Stage fuel pre-valve closed.		
		(6) Stage recirculation valve closed.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.18.1 (cont)		d. Dry engine fuel system by initiating purge at fuel inlet duct instrumentation port (downstream of pre-valve) with helium or gaseous nitrogen at 25-30 psig in gas supply line and 50° to 200° F (at purge inlet), with helium tank pressurized, and the following control valves energized, and measure humidity of gas emerging from thrust chamber exit:	Purge-drying must be performed for a minimum of 5 minutes and until humidity is within limits of figure 1-13.	Purge pressure must be zero until control valves are energized and helium tank pressurized. The following helium tank pressures are required: 225-250 psig at MTF and SAC/MDAC and 600-T, 600 psig at KSC. Flowrate through fuel flowmeter must not exceed 70 scfm with helium or 23 scfm with gaseous nitrogen. Engine propellant inlet duct pressures must not be greater than 5 psig and stage pre-valves must be closed before energizing engine pneumatic control valves.
		(1) Helium control.		
		(2) Ignition-phase control.		
		(3) Mainstage control.		
1.5.18.2	<u>Fuel System Drying for SII-Stage Engines</u>	a. Prepare the following flow paths:		
		(1) Stage recirculation pump and LH_2 return line valves closed.		
		(2) Stage fuel pre-valve closed.		
		(3) Fuel inlet duct instrumentation port downstream of pre-valve open.		
		b. Dry recirculation system by initiating purge at stage LH_2 purge disconnect with helium or gaseous nitrogen at 25-30 psig in gas supply line and 50° to 200° F (at purge inlet), and measure humidity of gas at fuel inlet duct instrumentation port downstream of pre-valve.	Purge-drying must be performed for a minimum of 15 minutes and until humidity is within limits of figure 1-13.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.18.2 (cont)		c. Prepare the following flow paths:		
		(1) Thrust chamber exit open.		Exit closure must be installed so as to partially cover exit.
		(2) Oxidizer turbine seal drain line open.		
		(3) Oxidizer turbopump primary seal drain line open.		
		(4) Oxidizer turbopump intermediate seal purge check valve vent line open.		
		(5) Stage fuel pre-valve closed.		
		(6) Stage recirculation and LH_2 return line valves closed.		
		d. Dry engine fuel system by initiating purge at fuel inlet duct instrumentation port (downstream of pre-valve) with helium or gaseous nitrogen at 25-30 psig in gas supply line and 50° to 200° F (at purge inlet), with helium tank pressurized, and the following control valves energized, and measure humidity of gas emerging from thrust chamber exit:	Purge-drying must be performed for a minimum of 5 minutes and until humidity is within limits of figure 1-13.	Purge pressure must be zero until control valves are energized and helium tank pressurized. The following helium tank pressures are required: 225-250 psig at MTF and SAC/MDAC and 600-1,600 psig at KSC. Flowrate through fuel flowmeter must not exceed 70 scfm with helium or 23 scfm with gaseous nitrogen. Engine propellant inlet duct pressures must not be greater than 5 psig and the stage pre-valves must be closed before energizing engine pneumatic control valves.
		(1) Helium control.		
		(2) Ignition-phase control.		
		(3) Mainstage control.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.19	<u>OXIDIZER SYSTEM DRYING</u>	Perform drying operations in paragraph 1.5.19.1 or 1.5.19.2, as applicable.		If oxidizer system drying is to be performed in sequence with thrust chamber jacket drying, thrust chamber drying must be performed first. During oxidizer feed system drying, air conforming to the requirements of MSFC-PROC-404 is an acceptable alternate drying agent for gaseous nitrogen.
1.5.19.1	<u>Oxidizer System Drying for SIVB-Stage Engines</u>	a. Prepare the following flow paths:		
		(1) Stage recirculation valve closed.		
		(2) Stage oxidizer prevalve closed.		
		(3) Instrumentation port on stage oxidizer recirculation return line open.		
		b. Dry recirculation system by initiating purge at oxidizer inlet duct instrumentation port (downstream of pre-valve) with helium or gaseous nitrogen at 25-30 psig in gas supply line, and 50° to 200° F (at purge inlet), and measure humidity of gas in stage oxidizer tank and at oxidizer recirculation return line instrumentation port.	Purge-drying must be performed for a minimum of 15 minutes and until humidity is within limits of figure 1-13.	
		c. Prepare the following flow paths:		
		(1) Thrust chamber exit open.		Exit closure must be installed so as to partially cover exit.
		(2) Oxidizer turbine seal drain open.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.19.1 (cont)		(3) Oxidizer turbopump primary seal drain line open.		
		(4) Oxidizer turbopump intermediate seal purge check valve vent line open.		
		(5) Stage oxidizer pre-valve closed.		
		(6) Stage recirculation valve closed.		
		d. Dry engine oxidizer system and ASI valve by initiating purge at oxidizer inlet duct instrumentation port (downstream of pre-valve) with helium or gaseous nitrogen at 25-30 psig in gas supply line and 50° to 200° F (at purge inlet), with helium tank pressurized, and the following control valves energized, and measure humidity of gas emerging from thrust chamber exit:		Purge pressure must be zero until control valves are energized and helium tank pressurized. The following helium tank pressures are required: 225-250 psig at MTF and SAC/MDAC and 600-1,600 psig at KSC. Flowrate through oxidizer flowmeter must not exceed 35 scfm with helium or 12 scfm with gaseous nitrogen. Engine propellant inlet duct pressures must not be greater than 5 psig and the stage pre-valves must be closed before energizing engine pneumatic control valves.
		(1) Oxidizer system drying:	Purge-drying must be performed for a minimum of 5 minutes and until humidity is within limits of figure 1-13.	
		(a) Helium control.		
		(b) Ignition-phase control.		
		(c) Mainstage control.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.19.1 (cont)		(2) ASI valve drying:	Purge-drying must be performed until humidity is within the limits of figure 1-13.	Mainstage control valve must be deenergized.
		(a) Helium control.		
		(b) Ignition-phase control.		
1.5.19.2	Oxidizer System Drying for SII-Stage Engines	a. Prepare the following flow paths:		
		(1) Stage recirculation oxidizer return line valve closed.		
		(2) Stage oxidizer pre-valve closed.		
		(3) Oxidizer inlet duct instrumentation port downstream of pre-valve open.		
		b. Dry recirculation system by initiating purge at stage recirculation oxidizer return line helium supply disconnect with helium or gaseous nitrogen at 25-30 psig in gas supply line and 50° to 200° F (at purge inlet), and measure humidity of gas at oxidizer inlet duct instrumentation port downstream of pre-valve.	Purge-drying must be performed for a minimum of 15 minutes and until humidity is within limits of figure 1-13.	
		c. Prepare the following flow paths:		
		(1) Thrust chamber exit open.		Exit closure must be installed so as to partially cover exit.
		(2) Oxidizer turbine seal drain line open.		
		(3) Oxidizer turbopump primary seal drain line open.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.19.2 (cont)		(4) Oxidizer turbopump intermediate seal purge check valve vent line open.		
		(5) Stage oxidizer pre-valve closed.		
		(6) Stage recirculation oxidizer return line valve closed.		
		d. Dry engine oxidizer system by initiating purge at oxidizer inlet duct instrumentation port (downstream of pre-valve) with helium or gaseous nitrogen at 25-30 psig in gas supply line and 50° to 200° F (at purge inlet), with helium tank pressurized, and the following control valves energized, and measure humidity of gas emerging from thrust chamber exit:	Purge-drying must be performed for a minimum of 5 minutes and until humidity is within limits of figure 1-13.	Purge pressure must be zero until control valves are energized and helium tank pressurized. The following helium tank pressures are required: 225-250 psig at MTF and SAC/MDAC and 600-1,600 psig at KSC. Flowrate through oxidizer flowmeter must not exceed 35 scfm with helium or 12 scfm with gaseous nitrogen.
		(1) Helium control.		
		(2) Ignition-phase control.		
		(3) Mainstage control.		Engine propellant inlet duct pressures must not be greater than 5 psig and stage pre-valves must be closed before energizing engine pneumatic control valves.
1.5.20	<u>GAS GENERATOR AND OXIDIZER LINE DRYING</u>			GG and fuel line drying must be performed following this drying operation.
		a. Prepare the following flow paths:		
		(1) Thrust chamber exit open.		Exit closure must be installed so as to partially cover exit.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.20 (cont)		(2) On SII-stage engines, oxidizer return valve closed.		
		(3) On SIVB-stage engines, stage oxidizer pre-valve and oxidizer recirculation system shutoff valve closed.		
		b. Actuate GG control valve open by pressurizing test plate installed on pneumatic opening control port to 225-250 psig.		Moisture must be prevented from entering GG control valve and pneumatic system while control line is disconnected.
		c. Initiate purge at the following inlet, as applicable, with helium or gaseous nitrogen at 25-30 psig in gas supply line and 50° to 200° F (at purge inlet) and measure humidity of gas emerging from thrust exit:	Purge-drying must be performed until humidity is within limits of figure 1-13 and for 2 more hours after humidity limits are attained.	Oxidizer recirculation system must be closed immediately upon conclusion of drying. Air conforming to the requirements of MSFC-PROC-404 is an acceptable alternate drying agent for gaseous nitrogen.
		(1) On SII-stage engines, stage oxidizer recirculation return line helium injection supply system.		
		(2) On SIVB-stage engines, instrumentation port on stage oxidizer recirculation return line.		
1.5.21	<u>GAS GENERATOR AND FUEL LINE DRYING</u>			If this operation is to be performed in a sequence with GG and oxidizer line drying, this operation must be performed after GG and oxidizer line drying is completed.
		a. Prepare the following flow paths:		
		(1) Thrust chamber exit.		Exit closure must be installed so as to partially cover exit.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.21 (cont)		(2) Stage LH_2 pre-valve closed.		
		(3) Stage recirculation system shutoff valve closed.		
		b. Actuate GG control valve open by pressurizing test plate installed on pneumatic opening control port to 225-250 psig.		Moisture must be prevented from entering GG control valve and pneumatic system while control line is disconnected.
		c. Initiate purge at instrumentation port in stage LH_2 recirculation system with helium or gaseous nitrogen at 25-30 psig in gas supply line and 50° to 200° F (at purge inlet) and measure humidity of gas emerging from thrust chamber exit.	Purge-drying must be performed until humidity is within limits of figure 1-13 and for 2 more hours after humidity limits are attained.	LH_2 recirculation system must be closed immediately upon conclusion of drying. Air conforming to the requirements of MSFC-PROC-404 is an acceptable alternate drying agent for gaseous nitrogen.
1.5.22	<u>START SYSTEM DRYING</u>	Perform drying operations outlined in paragraph 1.5.22.1 or 1.5.22.2, as applicable.		Purge-drying must be performed before vacuum-drying. Moisture must be prevented from entering start system during and at conclusion of drying operations.
1.5.22.1	<u>Start System Drying for Restart-Mission Engines</u>	a. Prepare the following flow paths:		
		(1) Start tank gaseous refill line disconnected from thrust chamber and blocked.		
		(2) START TANK INITIAL FILL customer-connect line disconnected and blocked.		
		(3) START TANK VENT & RELIEF VALVE DRAIN customer-connect line disconnected and blocked.		
		(4) Start tank vent-and-relief valve actuated open with START TANK VENT VALVE CONTROL customer connect pressurized to 585 psia maximum.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.22.1 (cont)		b. Initiate purge at liquid refill line flange (disconnected from ASI fuel line) with helium at 50 ±5 psig and 50° to 200° F (at purge inlet), and measure humidity of gas emerging from vent-and-relief valve drain line exit.	Purge-drying must be performed until humidity is within limits of figure 1-13 and for 2 more hours after humidity limits are attained.	
		c. Initiate purge at gaseous refill line flange (with liquid refill line blocked) with helium at 50 ±5 psig and 50° to 200° F (at purge inlet), and measure humidity of gas emerging from vent-and-relief valve drain line exit.	Purge-drying must be performed until humidity is within limits of figure 1-13 and for 2 more hours after humidity limits are attained.	Requirements in step a, sub-steps 2 through 4, remain applicable.
		d. Initiate purge at initial fill line customer connect (with liquid refill line blocked) with helium at 50 ±5 psig and 50° to 200° F (at purge inlet), and measure humidity of gas emerging from vent-and-relief valve drain line exit.	Purge-drying must be performed until humidity is within limits of figure 1-13 and for 2 more hours after humidity limits are attained.	Requirements in step a, sub-steps 1, 3, and 4, remain applicable.
		e. Connect lines between each of the following points and a vacuum manifold:		Vacuum manifold connections must be valved to enable isolating start system, vacuum pump, and a helium pressure supply from manifold and from each other.
		(1) START TANK INITIAL FILL customer connect.		
		(2) Start tank gaseous refill line flange.		
		(3) Start tank liquid refill line flange.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.22.1 (cont)		(4) START TANK VENT & RELIEF VALVE DRAIN customer connect.		
		(5) On engines on which MD336 change has not been accomplished following stage acceptance test, STDV outlet (with hose disconnected, swing gate held open by spacer, and STDV drain line to drain port connection blocked).		
		f. Evacuate start system through vacuum manifold to requirements of figure 1-14 with START TANK VENT VALVE CONTROL customer connect pressurized to 585 psia maximum to actuate vent-and-relief valve open.	Vacuum-drying must be performed for 3 hours minimum, including one hour minimum at required vacuum condition.	Step g is required at conclusion of vacuum-drying operation.
		g. Pressurize start system with helium through vacuum manifold to 2 psig maximum and deactuate vent-and-relief valve before disconnecting drying equipment and reconnecting engine lines.		
1.5.22.2	Start System Drying for Nonrestart-Mission Engines	Initiate purge at START TANK INITIAL FILL customer connect (disconnected from stage with helium at 50 ±5 psig and 50° to 200° F (at purge inlet), and measure humidity of gas emerging from START TANK VENT & RELIEF VALVE DRAIN customer connect (disconnected from stage) with START TANK VENT VALVE CONTROL customer connect pressurized to 585 psia maximum to actuate vent-and-relief valve open.	Purge-drying must be performed until humidity is within limits of figure 1-13 and for 2 more hours after humidity limits are attained.	
1.5.23	TURBINE AND EXHAUST SYSTEM DRYING	a. Open the following engine exits:		
		(1) Thrust chamber.		Exit closure must be installed so as to partially cover exit.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.23 (cont)		(2) Oxidizer turbine seal drain line.		
		(3) Oxidizer turbopump primary seal drain line (at thrust chamber exit).		
		(4) Oxidizer turbopump intermediate seal purge check valve vent line.		
		(5) Fuel turbine seal drain line.		
		b. Initiate purge at START TANK INITIAL FILL customer connect with helium at 500 psia maximum and 50° to 200° F (at purge inlet), with helium tank pressurized and the following control valves energized, and measure humidity of gas emerging from thrust chamber exit:	Purge-drying must be performed for a minimum of 15 minutes and until humidity is within limits of figure 1-13.	Purge pressure must be zero until control valves are energized and helium tank pressurized. The following helium tank pressures are required: 225-250 psig at MTF and SAC/MDAC and 600-1,600 psig at KSC.
		(1) Helium control.		Start tank pressure must be zero before STDV control valve is energized. Control valve must remain energized after start tank is pressurized. Purge pressure must be reduced to zero and start tank pressure allowed to vent to zero before STDV control valve is deenergized.
		(2) Ignition-phase control.		
		(3) Mainstage control.		
		(4) STDV control.		
1.5.24	PURGE MANIFOLD SYSTEM DRYING	a. Open the following engine exits:		
		(1) Thrust chamber.		Exit closure must be installed so as to partially cover exit.
		(2) Oxidizer and fuel turbine seal drain lines.		
		(3) Port in fuel turbopump primary seal drain line between turbopump and drain check valve.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.24 (cont)		b. Perform the following purge-drying operations consecutively:		
		(1) Initiate purge at purge manifold system line with helium at 67-115 psig and 50° to 200° F (at purge inlet), and measure humidity of gas emerging from port in fuel turbopump primary seal drain line.	Purge-drying must be performed until humidity is within limits of figure 1-13.	Purge pressure must be zero while plug is reinstalled in port in drain line; plug may be leak tested during drying operation in substep 2.
		(2) Resume purge-drying from substep 1, and measure humidity of gas emerging from oxidizer and fuel turbine seal drain lines.	Purge-drying must be continued until 2 hours of drying (including substep 1) have elapsed or until humidity is within limits of 1-13.	
1.5.25	<u>OXIDIZER DOME AND GAS GENERATOR OXIDIZER INJECTOR DRYING</u>			Pneumatic system pressure required for this operation exceeds personnel safe-operating limit at all test sites except KSC.
		a. Open the following engine exits:		
		(1) Thrust chamber.		Exit closure must be installed so as to partially cover exit.
		(2) Oxidizer turbine seal drain line.		
		(3) Oxidizer turbopump primary seal drain line.		
		(4) Oxidizer turbopump intermediate seal purge check valve vent line.		
		b. Initiate purge at helium tank fill line with helium at 1,400-1,600 psig (in helium tank under flow conditions) and 50° to 200° F (at customer connect) with helium control valve energized.	Purge-drying must be performed for 15 minutes.	

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.26	<u>PNEUMATIC SYSTEM DRYING</u>			This drying operation (or a 3-cycle engine sequence test) is required as the final purge-drying operation in a drying sequence in which engine pneumatic system has been opened or otherwise exposed to contamination subsequent to post-stage acceptance engine sequence testing. Pneumatic system pressure required for this operation exceeds personnel safe-operating limit at all test sites except KSC.
		a. Open the following engine exits:		
		(1) Thrust chamber.		Exit closure must be installed so as to partially cover exit.
		(2) Oxidizer turbine seal drain line.		
		(3) Oxidizer turbopump primary seal drain line.		
		(4) Oxidizer turbopump intermediate seal purge check valve vent line.		
		b. Initiate purge at helium tank fill line with helium at 1,400-1,600 psig (in helium tank under flow conditions) and 50° to 200° F (at customer connect) with helium control valve energized, and perform the following actuations and deactuations in the listed order a minimum of 3 times:		Purge pressure must be zero before helium control valve is energized. Fuel and oxidizer inlet duct pressure must be zero before control valves are energized.
		(1) Actuate ignition-phase control valve.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.26 (cont)		(2) Actuate mainstage control valve.		
		(3) Actuate STDV control valve.		Start tank pressure must be zero before STDV control valve is actuated.
		(4) Deactuate STDV control valve.		
		(5) Deactuate mainstage control valve.		
		(6) Deactuate ignition-phase control valve.		
		c. Reduce purge pressure to zero, allow pneumatic system pressure to bleed down to zero, and then deenergize helium control valve.		
1.5.27	<u>CALIPS CHECKOUT LINE DRYING</u>	a. Evacuate CALIPS CHECKOUT LINE customer-connect line (disconnected from stage) and mainstage OK pressure switches to requirements of figure 1-14.	Vacuum-drying must be performed for 1/2 hour minimum at required vacuum condition.	Calips checkout line drying is not required if stage system is provided with means for preventing entry of moisture into line. Gage used to measure absolute pressure in system must be accurate to ±1 millimeter at required vacuum condition. If a differential pressure gage is used, the measured value must be corrected for the barometric pressure of the location (including altitude) where drying is being done. Step b is required at conclusion of vacuum-drying operation.
		b. Pressurize calips checkout line and switches with helium to 2 psig maximum; then depressurize line before disconnecting drying equipment and reconnecting line.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.28	<u>GAS GENERATOR CONTROL VALVE, OXIDIZER TURBINE BYPASS VALVE, MAIN FUEL VALVE, MAIN OXIDIZER VALVE, AND ON ENGINES INCORPORATING MD366 OR MD371 CHANGE, MIXTURE RATIO CONTROL VALVE DRYING</u>	a. Connect vacuum system to vent ports on GG control valve adjustment plate and linkage housing of OTBV, MFV, MOV, and MRCV.		The GG control valve, OTBV, MFV, MOV, and MRCV linkage cavities may be dried individually or simultaneously. Gage used to measure absolute pressure in system must be accurate to ±1 millimeter at required vacuum condition. If a differential pressure gage is used, the measured value must be corrected for the barometric pressure of the location (including altitude) where drying is being done.
		b. Evacuate valve linkage cavities to requirements of figure 1-14.	Vacuum drying must be performed for 1/2 hour minimum at required vacuum condition.	Step c is required at conclusion of vacuum-drying operation.
		c. Pressurize valve linkage cavities with helium to 2 psig maximum, then depressurize before disconnecting drying equipment.		
		d. Install replacement vent port check valves.		
		e. (Deleted)		
1.5.29	<u>START TANK VENT-AND-RELIEF VALVE DRYING</u>			This requirement is for vacuum-drying vent-and-relief valve control cavity.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.29 (cont)				This drying operation is required before start tank chilldown for CDDT.
				Gage used to measure absolute pressure in system must be accurate to ±1 millimeter at required vacuum condition. If a differential pressure gage is used, the measured value must be corrected for the barometric pressure of the location (including altitude) where drying is being done.
		a. Evacuate start tank vent-and-relief valve control line to requirements of figure 1-14.	Vacuum-drying must be performed for 1/2 hour minimum at required vacuum condition.	Step b is required at conclusion of vacuum-drying operation.
		b. Pressurize vent valve control line with helium to 2 psig maximum; then depressurize line before disconnecting drying equipment.		
1.5.30	<u>OXIDIZER AND FUEL INLET DUCTS TORSIONAL BELLOWS DRYING</u>			The inlet duct torsional bellows drying must be performed at static test sites anytime ducts are exposed to cryogenic conditions.
				Leak-test torsional bellows as outlined in paragraph 1.3.66 after drying is completed.
		a. Remove inlet duct bellows protective covers.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.30 (cont)		b. Install heater on inlet duct torsional bellows flange joint with heater center tab located between boltheads on bolthead side of flange, outside tabs positioned with one tab on each side of one bipod set, and heater bolt connection located between two sets of bipods.		Contour of heater must mate with contour of duct flange.
		c. Center heater on flange joint, connect heater ends and tighten nut until rubber ends of heater butt against each other.		A 100 percent contact of heater end surfaces is not required.
		d. Install insulator blanket around heater with end of blanket located between two sets of bipods. Aline blanket cutouts around bipods and secure.		
		e. Measure resistance between engine and each pin on heater electrical connector.	Resistance must be greater than 100,000 ohms.	
		f. Apply 115 vac to heater. After approximately 10 minutes, feel bipods or inlet duct adjacent to insulator.	Bipods or duct must become warm to touch.	
		g. Operate heater continuously for a minimum of 8 hours if ambient temperature is below 50° F, 6 hours if ambient temperature is 50° to 80° F, and 4 hours if ambient temperature is 80° F or above.		
		h. Install inlet duct torsional bellows protective covers.		
1.5.31	<u>VENT PORT CHECK VALVE ACTUATION</u>	Manually actuate all engine vent port check valves.		This task is required before CDDT and within 60 days of launch.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.32	VENT PORT CHECK VALVE REPLACEMENT	a. Replace vent port check valves on the following components: (1) STDV control valve. (2) Fast shutdown valve (located at valve outlet port). (3) GG control valve. (4) OTBV (located on linkage housing). (5) MFV (located on linkage housing). (6) MOV (located on linkage housing). (7) MRCV (located on linkage housing). b. Replace the following vent port check valves on the helium regulator assembly: (1) Bleed regulator. (2) Main regulator exhaust. (3) Low-pressure relief valve. (4) Helium tank emergency vent valve.		Replace vent port check valves on GG control valve, OTBV, MFV, MOV, and MRCV after valve drying of paragraph 1.5.28.
1.5.33	THRUST CHAMBER TEMPERATURE TRANSDUCER HEAT SINK COMPOUND REPLACEMENT	Replace heat sink compound between thrust chamber temperature transducer and transducer mounting pad.		Must be performed within 6 months before launch.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6	HANDLING			
1.6.1	OXIDIZER AND FUEL INLET DUCT ALINEMENT	a. Inspect inlet duct null-point index marks scribed in 3 places on circumference of duct for duct alinement.	Total misalinement of 3 sets of index marks must not exceed 0.066 inch.	Inlet duct torsional bellows protective covers must be removed only as necessary to perform inspection or alinement and must be correctly reinstalled as soon as task is completed. If duct alinement is not within limits, steps b through e are required. Null adjuster set 9024540 is required.
		b. Remove three bolts from duct center flange, clevis pin that secures clevis to idler, and (on installed engines) bolts that secure inlet duct to stage.		Bolts and washers removed from inlet duct center flange must be marked for reinstallation in same holes.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.1 (cont)		c. Adjust null adjuster to position index mark on one ring beyond index mark on other ring, and hold this position long enough to relieve tension from duct.		Rotation beyond null position is necessary to relieve residual stresses and friction.
		d. Repeat step c as necessary to obtain acceptable alinement; then reinstall bolts and clevis pin.		
		e. Repeat inspection in accordance with requirements in step a.	Total misalinement of 3 sets of index marks must not exceed 0.066 inch.	
1.6.2	<u>ENGINE INSTALLATION</u>	Install engine in stage in accordance with requirements in paragraphs 1.6.2.1, 1.6.2.2, 1.6.2.3, and 1.6.2.4.		Gimbal mating (paragraph 1.6.2.1) must be performed before performing requirements in paragraph 1.6.2.2, 1.6.2.3, and 1.6.2.4. Oxidizer and fuel inlet ducts must be in alinement in accordance with paragraph 1.6.1.
1.6.2.1	<u>Gimbal Mating</u>	a. On engines not incorporating <u>MD287</u> change, remove vent port check valve from fuel inlet duct.		Vent port check valve must be reinstalled after fuel inlet duct is decompressed.
		b. Remove duct supports and flexible covers from oxidizer and fuel inlet ducts, and compress ducts approximately one inch.	Inlet ducts must be compressed sufficiently to clear mating connections when gimbal is mated.	Oxidizer and fuel inlet ducts are each normally 22.85 inches long and must not be compressed to less than 18.85 inches nor extended to more than 26.85 inches.
		c. Lift engine to installation (gimbal mating) position in accordance with the following requirements: (1) Within approximately 6 inches of gimbal mating position, remove protective closures from inlet ducts and corresponding stage connections.		Engine components must not be contacted or bumped by any engine installation equipment. Interface pneumatic fluid lines and electrical cables must be clear of all protruding objects during lifting operation.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.2.1 (cont)		(2) Within 2 inches of gimbal mating position, check gimbal alinement and adjust installation equipment as necessary to obtain alinement; inspect interface connections for clearance. (3) Within 1/8 to 3/8 inch of gimbal position, verify gimbal alinement and make adjustments, as necessary. (4) Raise engine into mated position, engaged 1/8 inch minimum, and install gimbal bolts. d. Install seals on inlet duct flanges, aline ducts with stage connections, decompress ducts, and install bolts that secure inlet ducts to stage.		
1.6.2.2	<u>Interface Fluid Line Support Removal</u>	a. Aline fluid lines with stage customer connections, remove customer-connect protective covers, and connect the following interface fluid lines, removing clamps and support lines, as necessary, while connecting to stage: (1) LOX BLEED LINE customer connect. (2) FUEL BLEED LINE customer connect. (3) START TANK INITIAL FILL customer connect. (4) HELIUM TANK FILL customer connect.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.2.2 (cont)		(5) HYDROGEN TANK PRESSURIZATION customer connect.		
		(6) OXIDIZER TANK PRESSURIZATION customer connect.		
		(7) FUEL PUMP DRAIN customer connect.		
		(8) START TANK VENT & RELIEF VALVE DRAIN customer connect.		
		(9) THRUST CHAMBER JACKET PURGE customer connect.		
		(10) PURGE MANIFOLD SYSTEM customer connect.		
		(11) CALIPS CHECKOUT LINE customer connect.		
		(12) OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect, on engines incorporating MD301, MD302, MD322, or MD323 change.		
		(13) HEAT EXCHANGER HELIUM INLET customer connect or SIVB-stage engines only.		
		(14) START TANK VENT VALVE CONTROL customer connect; connect to stage pneumatic control pressure line.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.2.2 (cont)		b. Remove remaining section of interface fluid line support from engine.		
1.6.2.3	<u>Interface Electrical Cable Connection</u>			Protective covers on cable and stage connectors must be removed only as each connection is performed. Cables and overmolds must not be pulled or twisted. Cables must not be bent to radius of less than one times outside diameter of cable. Rubber rings on electrical harness assemblies may be removed, if necessary, to prevent interference with stage mounting structure at upper electrical clamp block assembly. When rubber ring is cut for removal, rubber tubing and tie cord under ring must not be damaged.
		a. Disconnect each connector, one at a time, from panel on electrical interface support assembly.		
		b. Inspect electrical interface connectors for damage.	See figure 1-3 for damage limits.	
		c. (Deleted)		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.2.3 (cont)		d. (Deleted)		
		e. Connect the following interface electrical and instrumentation connectors, one at a time:		
		(1) P38.		
		(2) P51.		
		(3) P54.		
		(4) P105.		
		(5) P106.		
		(6) P107.		
		(7) P108.		
		(8) P109.		
		(9) P153.		
		(10) P154.		
		(11) P155.		
		(12) P156.		
		(13) P164, on engines incorporating MD329 or MD332 change.		
		(14) P167, on engines incorporating MD329 or MD332 change.		
		f. Remove electrical interface support assembly from engine interface cable support frame.		
1.6.2.4	Gimbal Actuator Connection	a. Connect gimbal actuator No. 1 to engine and install actuator pin.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.2.4 (cont)		b. Connect actuator No. 2 according to the following requirements:		
		(1) Disconnect struts 502290, 502464, and 502466 from electrical harness support frame, and strut 502466 from strut 502290.		Weight of electrical harness support frame must be supported until struts are reconnected.
		(2) Remove strut 502464.		
		(3) Remove fuel turbopump support link 407577.		Strut 502290 must be either pivoted to one side or, if necessary, removed from thrust chamber to provide access.
		(4) Connect gimbal actuator No. 2 to engine and install actuator pin.		
		(5) Reconnect fuel turbopump support link to turbopump and thrust chamber.		
		(6) Reinstall strut 502464.		
		(7) Reconnect struts 502290, 502464, and 502466.		
1.6.3	<u>ENGINE REMOVAL</u>	Remove engine from stage in accordance with requirements in paragraphs 1.6.3.1, 1.6.3.2, 1.6.3.3, and 1.6.3.4.		Gimbal demating (paragraph 1.6.3.4) must be performed last. Engine restrainer and film-cooled diffuser must be removed from engine before engine is removed from stage.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.3.1	Gimbal Actuator Disconnection	a. Disconnect gimbal actuator No. 1 from engine.		
		b. Disconnect actuator No. 2 according to the following requirements:		
		(1) Disconnect struts 502290, 502464, and 502466 from electrical harness support frame, and strut 502466 from strut 502290.		Weight of electrical harness support frame must be supported until struts are reconnected.
		(2) Remove strut 502464.		
		(3) Remove fuel turbopump support link 407577.		Strut 502290 must be either pivoted to one side or, if necessary, removed from thrust chamber to provide access.
		(4) Disconnect gimbal actuator No. 2 from engine.		
		(5) Reconnect fuel turbopump support link to turbopump and thrust chamber.		
		(6) Reinstall strut 502464.		
		(7) Reconnect struts 502290, 502464, and 502466.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.3.2	<u>Interface Electrical Cable Disconnection</u>			Protective covers on cable connectors must be installed as each disconnection is completed. Cables and overmolds must not be pulled or twisted. Cables must not be bent to radius of less than one times outside diameter of cable.
		a. Install electrical interface support assembly on engine interface cable support frame.		
		b. Disconnect interface electrical and instrumentation connectors listed in paragraph 1.6.2.3, one at a time.		Electrical power at engine interface must be off.
		c. Inspect connector for damage.	See figure 1-3 for damage limits.	
		d. Connect each connector to appropriate connector on outer panel of electrical interface support assembly.		
1.6.3.3	<u>Interface Fluid Line Support Installation</u>	a. Install fluid line support on engine with tube clamp assembly removed from support channel arm.		
		b. Disassemble tube clamp assembly and attach to support channel arm with support arms positioned adjacent to interface fluid lines.		
		c. Disconnect fluid lines listed in paragraph 1.6.2.2 from stage, and position and secure lines in tube support clamp.		Pressures at fluid line interface connections must be zero.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.5.3.3 (cont)		d. Swing out fluid line support, install arm lockpins, and install protective covers on fluid lines.		
1.6.3.4	Gimbal Demating	a. On engines not incorporating MD287 change, remove vent port check valve from fuel inlet duct.		Vent port check valve must be reinstalled after fuel inlet duct is decompressed.
		b. Disconnect oxidizer and fuel inlet ducts from stage and compress ducts approximately one inch.		Oxidizer and fuel inlet ducts are each normally 22.85 inches long and must not be compressed to less than 18.85 inches nor extended to more than 26.85 inches.
		c. Make sure that the follow- requirements are satisfied:		
		(1) Gimbal actuators disconnected from engine.		
		(2) Interface fluid lines disconnected from stage and installed in line support.		
		(3) Interface electrical cables disconnected from stage and connected to support panel.		
		(4) Clearance exists between overhead and adjacent structures and engine.		
		d. Remove gimbal bolts, lower engine from installation (gimbal mating) position, and install inlet duct protective closures with applicable quantity of desiccant.		
		e. Decompress inlet ducts, and install duct supports and flexible covers.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.4 through 1.6.12 (Deleted)				
1.6.13	<u>ENGINE COVER REMOVAL FOR STORAGE AND DURING INSPECTION AFTER ENGINE INSTALLATION IN STAGE</u>	Remove the following engine protective covers: a. Thrust chamber cover (exterior cover over tube assembly). b. Heat exchanger bellows covers. c. Four fuel inlet duct bellows covers. d. Four oxidizer inlet duct bellows covers. e. Two oxidizer turbine bypass duct bellows covers. f. Three turbine cross-over duct bellows covers. g. Twelve oxidizer and fuel inlet duct bipod covers. h. (Deleted) i. Three fuel bleed line covers. j. Oxidizer turbine seal drain line closure. k. Fuel turbine seal drain line closure. l. Oxidizer turbopump primary seal drain line protective closure. m. Oxidizer turbopump intermediate seal purge check valve vent line closure. n. Purge control valve vent line closure.		For engines stored in accordance with requirements of MSFC-STD-496, all covers and closures listed in this paragraph must be removed. For engines stored in accordance with requirements of MSFC-STD-498, all covers listed in steps a through i must be removed.
1.6.14 (Deleted)				

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.15	<u>ENGINE COVER AND CLOSURE REMOVAL FOR STAGE RECEIVING INSPECTION</u>	Remove the following engine protective covers, as applicable, for inspection to be performed: a. Thrust chamber exit closure. b. Thrust chamber cover. c. Heat exchanger bellows covers. d. Four fuel inlet duct bellows covers. e. Four oxidizer inlet duct bellows covers. f. Two oxidizer turbine bypass duct bellows covers. g. Three turbine crossover duct bellows covers. h. Twelve oxidizer and fuel inlet duct bipod covers. i. (Deleted) j. Three fuel bleed line covers.		Protective covers must be removed only as applicable inspection is performed; then covers must be correctly reinstalled as soon as inspection is completed. Refer to paragraph 1.6.20 for cover installation after stage receiving inspection, or paragraph 1.6.21.2 for cover installation after post-static-test securing and checkout.
1.6.16	<u>ENGINE COVER AND CLOSURE REMOVAL FOR INSPECTION AT VAB</u>	Remove the following engine protective covers, as applicable, for inspection to be performed: a. Heat exchanger bellows covers. b. Four fuel inlet duct bellows covers. c. Four oxidizer inlet duct bellows covers. d. Two oxidizer turbine bypass duct bellows covers. e. Three turbine crossover duct bellows covers. f. Three fuel bleed line covers.		Protective covers must be removed only as applicable inspection is performed; then covers must be reinstalled (paragraph 1.6.22) as soon as inspection is completed.
		g. Oxidizer turbopump primary seal stage overboard drain line.		When access is not feasible at the launch pad before CDDT, this closure may be removed before vehicle rollout and does not have to be reinstalled.

Pages 1-177 through 1-182 deleted.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.5 (cont)		d. Remove restrainer frame from fuel manifold and away from engine.		Restrainer must not bump engine components or lines.
1.6.6	<u>FILM-COOLED DIFFUSER INSTALLATION</u>	a. Install stiffener on diffuser and diffuser on engine thrust chamber.		
		b. Inspect clearance between deflector and diffuser.	Clearance must be 0.09 ±0.03 inch.	Correct clearance must be maintained during engine static-firing tests.
		c. Connect 2 water coolant lines to water manifold inlets, with a nitrogen purge line teed to one water line.	Diffuser coolant and purge must meet requirements in section II.	
		d. Monitor manifold pressure at instrumentation boss located about midway between water outlets.	Diffuser manifold (coolant) pressure must be sufficient to maintain a flowrate between 20 (minimum) and 24 (maximum) pounds of water per second.	Water must flow through all orifices and impinge upon diffuser skirt so as to provide good distribution and film cooling.
1.6.7	<u>FILM-COOLED DIFFUSER REMOVAL</u>	a. Inspect film-cooled diffuser for eroded or burned-through areas and restricted or plugged coolant holes.	Erosion, burn damage, or coolant hole interference is not allowable.	Discoloration due to heat is acceptable.
		b. Remove diffuser from engine thrust chamber.		
1.6.8	<u>VIBRATION SAFETY CUTOFF ACCELEROMETER INSTALLATION</u>	a. Install 3 VSC accelerometers in accelerometer bosses on engine thrust chamber dome or, on engines incorporating MD247 change, install 4 VSC accelerometers.		Accelerometer cables must be disconnected while accelerometers are being installed.
		b. Connect and secure accelerometer cables.		Cables must not be twisted, pulled, or secured to cryogenic lines or surfaces.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.9	VIBRATION SAFETY CUTOFF ACCELEROMETER REMOVAL	Remove VSC accelerometers and cables from engine.		Accelerometer cables must be disconnected while accelerometers are being removed. Cables must not be twisted or pulled.
1.6.10	OXIDIZER AND FUEL INLET DUCT BIPOD PIN REPOSITIONING			This activity is required if pin installation is not within limits when inspected.
		a. Reposition retaining pin.	Retaining pin must protrude a minimum of 1/16 inch on either side of pivot pin.	Retaining pin should protrude approximately equal amounts on either side of pivot pin.
		b. Inspect pin for damage.	Slight burring of pin resulting from interference fit is acceptable.	
1.6.11	IGNITION DETECTOR PROBE REPLACEMENT	Remove spent ignition detector probe and install new probe before next engine static-firing test.		
1.6.12	GAS GENERATOR OVERTEMPERATURE TRANSDUCER REPLACEMENT	Remove GG overtemperature transducer GGT1 and install new transducer before next engine static-firing test.		This requirement applies only if engine cutoff was caused by a GG overtemperature condition during static-firing test.
1.6.13	ENGINE COVER REMOVAL FOR STORAGE AND DURING INSPECTION AFTER ENGINE INSTALLATION IN STAGE	Remove the following engine protective covers:		For engines stores in accordance with requirements of MSFC-STD-496 or MSFC-STD-498 only, all covers listed in this paragraph must be removed.
		a. Thrust chamber cover (exterior cover over tube assembly).		
		b. Heat exchanger bellows covers.		For post-installation inspection, covers must be removed only as applicable inspection is performed; then covers must be reinstalled (paragraph 1.6.19) as soon as inspection is completed.
		c. Four fuel inlet duct bellows covers.		
		d. Four oxidizer inlet duct bellows covers.		
		e. Two oxidizer turbine bypass duct bellows covers.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.13 (cont)		f. Three turbine cross-over duct bellows covers.		
		g. Twelve oxidizer and fuel inlet duct bipod covers.		
		h. (Deleted)		
		i. Three fuel bleed line covers.		
1.6.14	<u>ENGINE COVER AND CLOSURE REMOVAL FOR PRE-STATIC-TEST CHECKOUT AND PREPARATION</u>	Remove engine protective covers, as applicable, in accordance with paragraph 1.6.14.1 for inspection before static test, and remove covers and closures in accordance with paragraph 1.6.14.2 as near time of static test as possible.		
1.6.14.1	<u>Engine Cover Removal for Pre-Static-Test Inspection</u>	Remove the following engine protective covers, as applicable, for inspection to be performed:		Protective covers must be removed only as applicable inspection task in paragraph 1.1.14.1 is performed; then covers must be reinstalled (paragraph 1.6.19) as soon as inspection is completed.
		a. Thrust chamber cover (exterior cover over tube assembly).		
		b. Heat exchanger bellows covers.		
		c. Four fuel inlet duct bellows covers.		
		d. Four oxidizer inlet duct bellows covers.		
		e. Two oxidizer turbine bypass duct bellows covers.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.14.1 (cont)		f. Three turbine cross-over duct bellows covers.		
		g. Twelve oxidizer and fuel inlet duct bipod covers.		
		h. (Deleted)		
		i. Three fuel bleed line covers.		
1.6.14.2	<u>Engine Cover and Closure Removal for Static-Test Firing</u>	Remove the following engine covers and closures:		Remove covers and closures as near time of static-test firing as practical.
		a. Thrust chamber exit closure.		
		b. Thrust chamber cover.		
		c. Heat exchanger bellows covers.		
		d. Four fuel inlet duct bellows covers.		
		e. Four oxidizer inlet duct bellows covers.		
		f. Two oxidizer turbine bypass duct bellows covers.		
		g. Three turbine crossover duct bellows covers.		
		h. Twelve oxidizer and fuel inlet duct bipod covers.		
		i. (Deleted)		
		j. Three fuel bleed line covers.		
		k. Oxidizer turbine seal drain line closure.		
		l. Fuel turbine seal drain line closure.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.14.2 (cont)		m. Oxidizer turbopump primary seal drain line closure (stage overboard drain line and burst diaphragm protective closure on engines incorporating MD301, MD302, MD322, or MD323 change).		
		n. Oxidizer turbopump intermediate seal purge check valve vent line closure.		
		o. Fuel turbopump primary seal drain line closure (stage overboard line).		
		p. Purge control valve vent line closure (on engines not incorporating MD166 change and on engines incorporating MD301, MD302, MD322, or MD323 change).		
		q. Oxidizer inlet duct torsional bellows flange cover and tape from 6 drain holes on downstream side of center flange joint.		
		r. Fuel inlet duct torsional bellows flange cover and tape from 6 drain holes on downstream side of center flange joint.		Some fuel inlet ducts do not contain drain holes.
1.6.15	ENGINE COVER AND CLOSURE REMOVAL FOR STAGE RECEIVING INSPECTION AND POST-STATIC-TEST INSPECTION	Remove the following engine protective covers, as applicable, for inspection to be performed: a. Thrust chamber exit closure. b. Thrust chamber cover. c. Heat exchanger bellows covers. d. Four fuel inlet duct bellows covers. e. Four oxidizer inlet duct bellows covers.		Protective covers must be removed only as applicable inspection is performed; then covers must be correctly reinstalled as soon as inspection is completed. Refer to paragraph 1.6.20 for cover installation after stage receiving inspection, or paragraph 1.6.21.2 for cover installation after post-static-test securing and checkout.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.15 (cont)		f. Two oxidizer turbine bypass duct bellows covers.		
		g. Three turbine cross-over duct bellows covers.		
		h. Twelve oxidizer and fuel inlet duct bipod covers.		
		i. (Deleted)		
		j. Three fuel bleed line covers.		
1.6.16	<u>ENGINE COVER AND CLOSURE REMOVAL FOR INSPECTION AT VAB</u>	Remove the following engine protective covers, as applicable, for inspection to be performed:		Protective covers must be removed only as applicable inspection is performed; then covers must be reinstalled (paragraph 1.6.22) as soon as inspection is completed.
		a. Heat exchanger bellows covers.		
		b. Four fuel inlet duct bellows covers.		
		c. Four oxidizer inlet duct bellows covers.		
		d. Two oxidizer turbine bypass duct bellows covers.		
		e. Three turbine cross-over duct bellows covers.		
		f. Three fuel bleed line covers.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.17	ENGINE COVER AND CLOSURE REMOVAL FOR COUNTDOWN DEMONSTRATION TEST	Remove the following engine covers and closures: a. Thrust chamber exit closure. b. Thrust chamber cover. c. Heat exchanger bellows covers. d. Four fuel inlet duct bellows covers. e. Four oxidizer inlet duct bellows covers. f. Two oxidizer turbine bypass duct bellows covers. g. Three turbine crossover duct bellows covers. h. Twelve oxidizer and fuel inlet duct bipod covers. i. Closures on the following electrical connectors: (1) J160. (2) J163. (3) P161 (on engines incorporating MD172 change but not incorporating MD185 change). (4) J22 (on engines incorporating MD160 change). (5) P157 (on engines incorporating MD100 change). (6) J19 (on engines incorporating MD338 change). j. Three fuel bleed line covers. k. Oxidizer turbine seal drain line closure. l. Fuel turbine seal drain line closure.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.17 (cont)		m. Oxidizer turbopump primary seal drain line burst diaphragm protective closure.		
		n. Oxidizer turbopump intermediate seal purge check valve vent line closure.		
		o. Verify removal of fuel turbopump primary seal drain stage overboard line closure.		
		p. Purge control valve vent line closure.		
		q. Oxidizer inlet duct torsional bellows flange cover.	On engines incorporating MD251 or MD252 change, 3 insulators 146004 must be installed on oxidizer inlet duct.	
		r. Fuel inlet duct torsional bellows flange cover.		
		s. Remove tape from the 6 drain holes on oxidizer inlet duct.		
		t. Remove tape from the 6 drain holes on fuel inlet duct.		Some fuel inlet ducts do not contain drain holes.
		u. Twelve electrical harness protective covers (located between electrical harness clamping blocks).		
		v. Twelve electrical harness protective covers (located between clamping block and customer-connect panel).		
1.6.18	ENGINE COVER AND CLOSURE REMOVAL FOR LAUNCH PREPARATION	Remove the following engine covers and closures: a. Thrust chamber exit closure. b. Thrust chamber cover. c. Heat exchanger bellows covers. d. Four fuel inlet duct bellows covers. e. Four oxidizer inlet duct bellows covers. f. Two oxidizer turbine bypass duct bellows covers.		Remove covers and closures as near time of launch as practical. This paragraph lists all applicable covers and closures, some of which may be already removed, since installation of engine covers and closures after CDDT is only required to protect areas of engine exposed to possible damage when performing maintenance (refer to paragraph 1.6.23).

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.18 (cont)		g. Three turbine crossover duct bellows covers.		
		h. Twelve oxidizer and fuel inlet duct bipod covers.		
		i. Helium high-pressure relief valve dust cover (on engines incorporating MD272 or MD362 change).		
		j. Three fuel bleed line covers.		
		k. Oxidizer turbine seal drain line closure.		
		l. Fuel turbine seal drain line closure.		
		m. Oxidizer turbopump primary seal drain line burst diaphragm protective closure.		
		n. Oxidizer turbopump intermediate seal purge check valve vent line closure.		
		o. Fuel turbopump primary seal drain line closure (stage overboard line).		
		p. Purge control valve vent line closure.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.18 (cont)		q. Twelve electrical harness protective covers (located between electrical harness clamping blocks).		
		r. Twelve electrical harness protective covers (located between clamping block and customer-connect panel).		
		s. Oxidizer inlet duct torsional bellows flange cover.		On engines incorporating MD251 or MD252 change, 3 insulators 146004 must be installed on oxidizer inlet duct.
		t. Fuel inlet duct torsional bellows flange cover.		
		u. Remove tape from the 6 drain holes on oxidizer inlet duct.		
		v. Remove tape from the 6 drain holes on fuel inlet duct.		Some fuel inlet ducts do not contain drain holes.
		w. Closures on the following electrical connectors:		
		(1) J160.		
		(2) J163.		
		(3) P161 (on engines incorporating MD172 change but not incorporating MD185 change).		
		(4) J22 (on engines incorporating MD160 change).		
		(5) P157 (on engines incorporating MD100 change).		
		(6) J19 (on engines incorporating MD338 change).		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.19	<u>ENGINE COVER INSTALLATION AFTER REMOVAL FROM STORAGE, DURING INSPECTION AFTER ENGINE INSTALLATION IN STAGE, AND DURING PRE-STATIC-TEST INSPECTION</u>	Install the following engine protective covers:		Post-storage cover installation requirements are applicable to engines that were stored in accordance with MSFC-STD-496 or MSFC-STD-498.
		a. Thrust chamber cover (exterior cover over tube assembly).		
		b. Heat exchanger bellows covers.		
		c. Four fuel inlet duct bellows covers.		
		d. Four oxidizer inlet duct bellows covers.		
		e. Two oxidizer turbine bypass duct bellows covers.		
		f. Three turbine cross-over duct bellows covers.		
		g. Twelve oxidizer and fuel inlet duct bipod covers.		
		h. (Deleted)		
		i. Three fuel bleed line covers.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.20	ENGINE COVER AND CLOSURE INSTALLATION AFTER STAGE RECEIVING INSPECTION	Install the following engine protective covers:		
		a. Thrust chamber exit closure.		Desiccant must be installed with thrust chamber exit closure.
		b. Thrust chamber cover.		
		c. Heat exchanger bellows covers.		
		d. Four fuel inlet duct bellows covers.		
		e. Four oxidizer inlet duct bellows covers.		
		f. Two oxidizer turbine bypass duct bellows covers.		
		g. Three turbine crossover duct bellows covers.		
		h. Twelve oxidizer and fuel inlet duct bipod covers.		
		i. (Deleted)		
		j. Three fuel bleed line covers.		

1.6.21 (Deleted)

All data on pages 1-189 and 1-190 deleted.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.21.1	<u>Engine Cover And Closure Installation After Stage Static Test (Complete or Abort/Reschedule)</u>	Install the following engine covers and closures:		External areas of engine must be dry before covers and closures are installed.
		a. Thrust chamber exit closure.		Injector must be free of frost or moisture.
		b. Thrust chamber cover.		Desiccant must be installed with closures, as required.
		c. Heat exchanger bellows covers.		
		d. Four fuel inlet duct bellows covers.		
		e. Four oxidizer inlet duct bellows covers.		
		f. Two oxidizer turbine bypass duct bellows covers.		
		g. Three turbine crossover duct bellows covers.		
		h. Twelve oxidizer and fuel inlet duct bipod covers.		
		i. (Deleted)		
		j. Three fuel bleed line covers.		
		k. Oxidizer turbine seal drain line closure.		
		l. Fuel turbine seal drain line closure.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.21.1 (cont)		m. Oxidizer turbopump primary seal drain line closure (stage overboard drain line and burst diaphragm protective closure on engines incorporating MD301, MD302, MD322, or MD323 change).		
		n. Oxidizer turbopump intermediate seal purge check valve vent line closure.		
		o. Fuel turbopump primary seal drain line closure (stage overboard line).		
		p. Purge control valve vent line closure (on engines not incorporating MD166 change and on engines incorporating MD301, MD302, MD322, or MD323 change).		
1.6.21.2	Engine Cover Installation After Inspection During Post-Static-Test Securing and Checkout	Install the following engine protective covers:		
		a. Thrust chamber cover (exterior cover over tube assembly).		
		b. Heat exchanger bellows covers.		
		c. Four fuel inlet duct bellows covers.		
		d. Four oxidizer inlet duct bellows covers.		
		e. Two oxidizer turbine bypass duct bellows covers.		
		f. Three turbine crossover duct bellows covers.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.22	ENGINE COVER INSTALLATION AFTER INSPECTION AT VAB	Install the following engine protective covers: a. Heat exchanger bellows covers. b. Four fuel inlet duct bellows covers. c. Four oxidizer inlet duct bellows covers. d. Two oxidizer turbine bypass duct bellows covers. e. Three turbine cross-over duct bellows covers. f. Three fuel bleed line covers.		
1.6.23	ENGINE COVER AND CLOSURE INSTALLATION FOR COUNTDOWN DEMONSTRATION TEST SECURING	Install covers and closures in accordance with paragraph 1.6.23.1 after countdown demonstration test, and install protective covers, as applicable, in accordance with paragraph 1.6.23.2, after inspection tasks are completed during countdown demonstration test securing.		Installation of engine closures is not required after countdown demonstration test if interstage environmental control system is to remain on. Installation of engine covers is required, as applicable, to protect areas of engine exposed to possible damage when performing unscheduled maintenance in the interstage.

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.23.1	Engine Cover and Closure Installation After Countdown Demonstration Test	Install the following engine covers and closures:		External areas of engine must be dry before covers and closures are installed.
		a. Thrust chamber exit closure.		
		b. Thrust chamber cover.		Injector must be free of frost or moisture.
		c. Heat exchanger bellows covers.		Desiccant must be installed with closures, as required.
		d. Four fuel inlet duct bellows covers.		
		e. Four oxidizer inlet duct bellows covers.		
		f. Two oxidizer turbine bypass duct bellows covers.		
		g. Three turbine crossover duct bellows covers.		
		h. Twelve oxidizer and fuel inlet duct bipod covers.		
		i. (Deleted)		
		j. Three fuel bleed line covers.		
		k. Oxidizer turbine seal drain line closure.		
		l. Fuel turbine seal drain line closure.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.23.1 (cont)		m. Oxidizer turbopump primary seal drain line burst diaphragm protective closure.		
		n. Oxidizer turbopump intermediate seal purge check valve vent line closure.		
		o. Fuel turbopump primary seal drain line closure (stage overboard line).		
		p. Purge control valve vent line closure.		
		q. Oxidizer inlet duct torsional bellows flange cover.		
		r. Fuel inlet duct torsional bellows flange cover.		
1.6.23.2	<u>Engine Cover and Closure Installation After Inspection During Countdown Demonstration Test Securing</u>	Install the following engine protective covers:		
		a. Thrust chamber exit closure.		Desiccant must be installed with thrust chamber exit closure.
		b. Thrust chamber cover.		
		c. Four fuel inlet duct bellows covers.		
		d. Four oxidizer inlet duct bellows covers.		
		e. Three fuel bleed line covers.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.24	ENGINE COVER AND CLOSURE INSTALLATION AFTER LAUNCH COUNTDOWN ABORT/ RESCHEDULE	Install the following engine covers and closures.		External areas of engine must be dry before covers and closures are installed.
		a. Thrust chamber exit closure.		
		b. Thrust chamber cover.		Injector must be free of frost or moisture.
		c. Heat exchanger bellows covers.		Desiccant must be installed with closures, as required.
		d. Four fuel inlet duct bellows covers.		
		e. Four oxidizer inlet duct bellows covers.		
		f. Two oxidizer turbine bypass duct bellows covers.		
		g. Three turbine crossover duct bellows covers.		
		h. Twelve oxidizer and fuel inlet duct bipod covers.		
		i. Helium high-pressure relief valve dust cover (on engines incorporating MD272 or MD362 change).		
		j. Three fuel bleed line covers.		
		k. Oxidizer turbine seal drain line closure.		
		l. Fuel turbine seal drain line closure.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.24 (cont)		m. Oxidizer turbopump primary seal drain line burst diaphragm protective closure.		
		n. Oxidizer turbopump intermediate seal purge check valve vent line closure.		
		o. Fuel turbopump primary seal drain line closure (stage overboard line).		
		p. Purge control valve vent line closure.		
1.6.25	ENGINE COVER AND CLOSURE INSTALLATION FOR ENGINE REMOVAL FROM STAGE	Install the following engine covers and closures:		This paragraph lists all applicable covers and closures, some of which may be already installed. Desiccant must be installed with closures, as required.
		a. Two oxidizer and fuel inlet duct covers.		
		b. Thrust chamber exit closure.		
		c. Thrust chamber cover.		
		d. Heat exchanger bellows covers.		
		e. Four fuel inlet duct bellows covers.		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.25 (cont)		f. Four oxidizer inlet duct bellows covers.		
		g. Two oxidizer turbine bypass duct bellows covers.		
		h. Three turbine crossover duct bellows covers.		
		i. Twelve oxidizer and fuel inlet duct bipod covers.		
		j. Helium high-pressure relief valve duct cover (on engines incorporating MD272 or MD362 change).		
		k. Three fuel bleed line covers.		
		l. Oxidizer turbine seal drain line closure.		
		m. Fuel turbine seal drain line closure.		
		n. Oxidizer turbopump primary seal drain line stage overboard drain line and burst diaphragm protective closures.		
		o. Oxidizer turbopump intermediate seal purge check valve vent line closure.		
		p. Fuel turbopump primary seal drain line closure (stage overboard line).		

Paragraph	Activities	Requirements	Limits	Special Constraints and Remarks
1.6.25 (cont)		q. Purge control valve vent line closure.		
		r. Closures on the following electrical connectors:		
		(1) J160.		
		(2) J163.		
		(3) P161 (on engines incorporating MD172 change but not incorporating MD185 change).		
		(4) J22 (on engines incorporating MD160 change).		
		(5) P157 (on engines incorporating MD100 change).		
		(6) J19 (on engines incorporating MD338 change).		
		s. Oxidizer inlet duct torsional bellows flange cover.		
		t. Fuel inlet duct torsional bellows flange cover.		

Condition	Limits
THRUST CHAMBER	
Tube scratches (internal and external)	Metal removal up to 0.001 inch deep by 0.010 inch wide is acceptable.
Tube dents:	
a. Metal removed	Metal removal up to 0.001 inch deep by 0.010 inch wide is acceptable.
b. Within combustion zone and including area 6 inches aft of throat	Maximum of 50 dents up to 0.020 inch deep is acceptable.
c. Exterior areas of chamber and inside chamber (but outside combustion zone, including area 6 inches aft of throat)	Maximum of 350 dents up to 0.060 inch deep is acceptable.
Tube discoloration (dark spots or streaks) with no metal removed	Acceptable condition.
Transverse cracks in tubes in combustion zone	Acceptable condition.
External transverse cracks in tubes	Cracks are not allowable.
Tube erosion (strong evidence of metal removal)	Erosion is not allowable.
Longitudinal splits in tubes in combustion zone	Splits are not allowable.
Tube pinholes	Pinholes are not allowable.
Cracks in braze joints or apparent lack of braze between tubes	Acceptable condition if joint does not leak.
Weld or parent metal cracks	Cracks are not allowable.
Turbine exhaust manifold dents	Up to 0.25 inch deep with a 1-inch minimum radius is acceptable.
Turbine exhaust manifold cracks	Cracks are not allowable.
Insulation damage	Damage is not allowable.
START TANK, INSULATION, AND COVER	
Fiberglass cover cracks, indentations, holes, splits, and burned, cut, or shattered areas	Damage is not allowable.

Figure 1-3. Engine Damage Limits (Sheet 1 of 4)

Condition	Limits
START TANK, INSULATION, AND COVER (continued)	
Fiberglass cover painted surface chips, cracks, scratches, blisters, peeling, or other damage	Damage is not allowable.
Broken bond between potting compound and tank or fiberglass cover	Broken bonds are not allowable.
Wet insulation (due to extensive damage to fiberglass cover or potting)	Wet insulation is not allowable.
Tank surface dented, scratched, cut, or damaged by excessive heat (brown, white, or scaly surface)	Damage is not allowable.
HEAT EXCHANGER	
Scratches or grind marks in shell parent material or weld (not sealing surfaces)	Up to 5 percent of material thickness is acceptable.
Dents in shell	Up to 0.25 inch deep with a 1-inch minimum radius is acceptable.
Cracks in welds or parent material of shell	Cracks are not allowable.
Cracks in bellows	Cracks are not allowable.
FUEL AND OXIDIZER INLET DUCT BELLOWS (CONVOLUTIONS)	
Dents or surface irregularities in other than critical regions on formed metal bellows	Up to 0.010 inch is acceptable.
Dents or surface irregularities in critical regions on formed metal bellows	Acceptable depth and length of surface irregularities is determined by convolution height, as shown in figure 1-4.
FUEL TURBOPUMP INSULATED VOLUTE COVER AND POTTING	
Depressions, dents, gouges, and creases in cover	Depressions, dents, gouges, and creases are acceptable if cover is not punctured.
Cracks or punctures in cover	Cracks or punctures are not allowable.
Cracked or peeling potting	Cracks and peeling are not allowable.
FUEL BLEED LINE AND MOUNTING BRACKET INSULATION	
Depressions, creases, and scratches	Depressions, creases, and scratches are acceptable if tape is not punctured to a depth that exposes Micro-Fiber felt.
Cracks or cuts in tape	Cracks or cuts in tape that expose Micro-Fiber felt are not allowable.

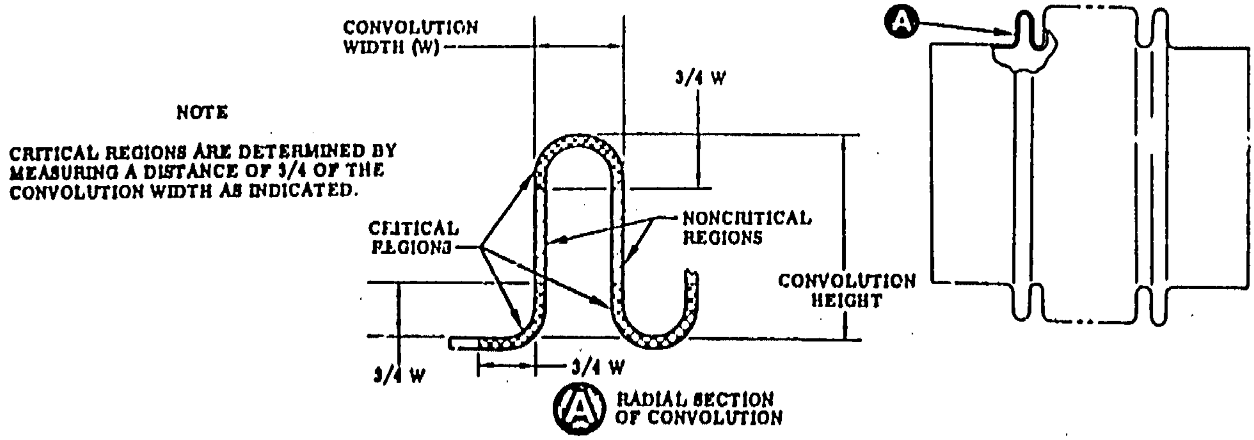
Figure 1-3. Engine Damage Limits (Sheet 2 of 4)

Condition	Limits
ARMORED HARNESS	
Raised braid (braid not broken)	Acceptable if increase in harness diameter is less than 5 percent of harness cross-sectional area.
Loose braid	Up to 0.150 inch metallic braid separation or up to one percent of rubber tubing visible through braid in any one linear foot of harness is acceptable.
Random individual broken braid strands	Acceptable condition.
Broken braid carriers	Damage is not allowable.
Wire insulation cut	Damage is not allowable.
Harness contaminated	Contamination is not allowable.
Green or black (polyurethane) overmold:	
a. Voids between overmold and armor braid	Up to 0.25 inch void is acceptable.
b. Cracks, cuts, or holes that do not expose armor braid	Acceptable condition.
c. Thermal damage (charred)	Damage is not allowable.
Heat-shrinkable (black silicone rubber) overmold:	
a. Voids between overmold and armor braid	Up to 0.25 inch void is acceptable.
b. Blisters, holes, scratches, or gouges	Up to 1/8 inch in diameter is acceptable.
c. Unbonded areas at each end of overmold	Acceptable provided overmold is not loose or slipping on harness.
d. Thermal damage (charred)	Damage is not allowable.
Heat-shrinkable tubing:	
a. Blisters, nicks, or scratches	Up to 1/8 inch in diameter is acceptable.
b. Cuts (no damage to wire insulation)	Up to one inch in length is acceptable.
Thermal protecting boot:	
a. Surface scratches, nicks, or gouges	Up to 1/8 inch in diameter and up to 0.030 inch in depth is acceptable.
b. Torn ears on boot	Damage is not allowable.

Figure 1-3. Engine Damage Limits (Sheet 3 of 4)

Condition	Limits
ELECTRICAL CONNECTOR	
Contact pins (male) bent or cracked	Bends or cracks are not allowable.
Contact sockets (female) bent or misalined	Bends or misalinements are not allowable.
Contact pins or sockets corroded (determined visually by using 4-power (maximum) magnification)	Corrosion is not allowable.
Contact pins or sockets extended or recessed:	
a. 16-gage contact pins in shell sizes 12, 14, 16, and 18 through 36.	Acceptable distance between crown of pin and a point level with top of plug shell is 0.281 (+0.030, -0.042) inch, as shown in figure 1-5.
b. 12- and 16-gage contact pins in shell sizes 8S, 10S, 10SL, 12S, 14S, and 16S.	Acceptable distance between crown of pin and a point level with top of plug shell is 0.094 (+0.030, -0.042) inch, as shown in figure 1-5.
c. Contact sockets.	Acceptable distance between top of socket and a point level with top of receptacle shell is 0.094 (+0.030, -0.042) inch, as shown in figure 1-5.
Connector insert cracked or split	Damage is not allowable.
Connector shell broken	Damage is not allowable.
Connector sealing surfaces damaged (nicks, burs, or scratches)	Acceptable provided that sealing function is not impaired.
SPARK IGNITER CABLE	
Spark igniter cable ablative protective covering	Surface imperfections, nicks, scratches, and cuts one inch in length or less in covering are acceptable providing wire braid or bellows beneath braid is not exposed or damaged.
FLEX HOSE BRAID	
Broken or chafed wires within one inch of braid retaining collar	Broken wires are not allowable. Chafed wires with more than 30 percent of material worn away are not allowable.
Broken wires in a carrier (group of parallel wires woven from one braid collar to the other)	Maximum of one broken wire is acceptable.
Broken wires in adjacent, parallel carriers	Broken wires in adjacent, parallel carriers are not allowable.
Broken wires in entire flex hose	Maximum of 6 broken wires is allowable.
Braid damage	Severe kinking of a group of wires or visible dents in braid cover is not allowable.
Bulges	Bulges that extend beyond outside diameter or hex flat dimension of braid retaining collar are not allowable.

Figure 1-3. Engine Damage Limits (Sheet 4 of 4)



CONVOLUTION HEIGHT		DENT	
GREATER THAN (INCHES)	LESS THAN (INCHES)	MAXIMUM LENGTH (INCHES)	MAXIMUM DEPTH (INCHES)
0	1/4	1/4	0.0005
1/4	1/2	1/2	0.001
1/2	2	1	0.002

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Figure 1-4. Acceptable Damage Limits for Surface Irregularities in Critical Regions on Metal Bellows

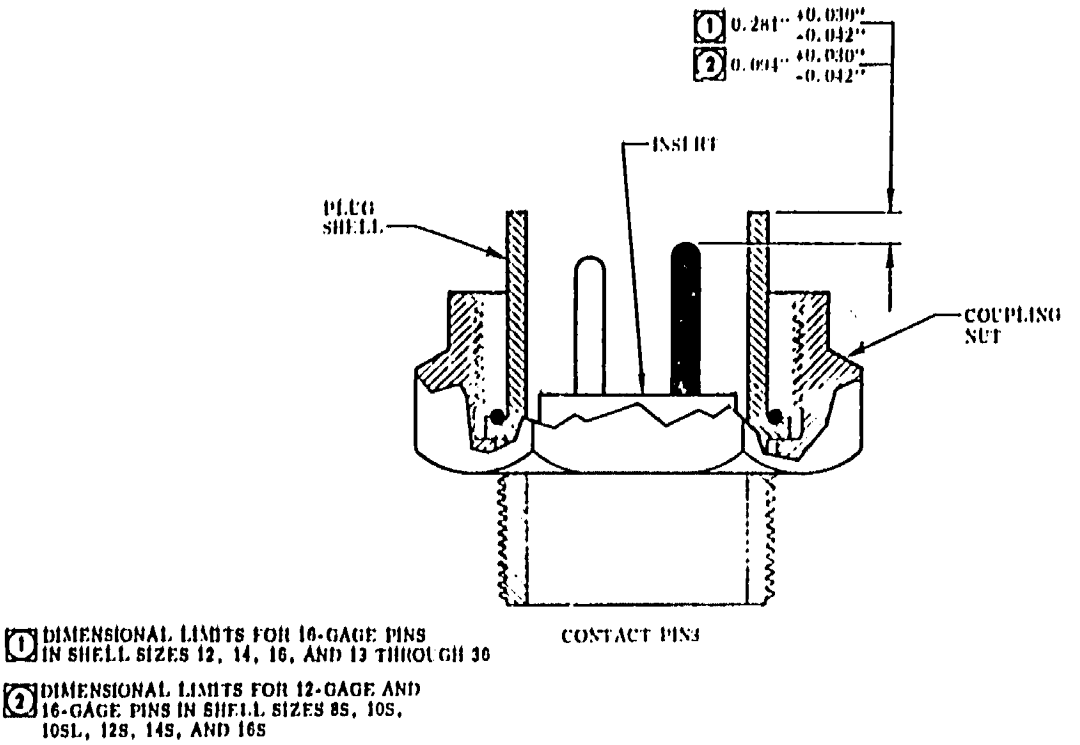

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Figure 1-5. Acceptable Damage Limits for Electrical Connector Pins

Tap Identification	Pressure Parameter	Range (psia)	Voltage Limits (vdc)[a] Initial	20 Percent	80 Percent
PF3	Fuel turbopump discharge	0-1,500	-0.400 to +0.500	0.600 to 1.500	3.600 to 4.500
P03	Oxidizer turbopump discharge	0-1.500 0-2,000[b]	-0.400 to +0.500 -0.413 to +0.487	0.600 to 1.500 0.587 to 1.487	3.600 to 4.500 3.587 to 4.487
CG1	Thrust chamber	0-1,000	-0.375 to +0.525	0.625 to 1.525	3.625 to 4.525
NN1	Helium tank	0-3,500	-0.428 to +0.322	0.572 to 1.322	3.572 to 4.322
NN1	Helium tank (redundant)	0-3,500[c] 0-5,000[d]	-0.428 to +0.322 -0.435 to +0.465	0.572 to 1.322 0.565 to 1.465	3.572 to 4.322 3.565 to 4.465
TF1	Start tank	0-1,500	-0.400 to +0.350	0.600 to 1.350	3.600 to 4.350
TF1	Start tank (redundant)	0-1,500[e] 0-3,500[f]	-0.400 to +0.350 -0.428 to +0.472	0.600 to 1.350 0.572 to 1.472	3.600 to 4.350 3.572 to 4.472
CF2	Main fuel injection	0-1,000 0-1,500[b]	-0.375 to +0.525 -0.400 to +0.500	0.625 to 1.525 0.600 to 1.500	3.625 to 4.525 3.600 to 4.500
C03	Main oxidizer injection	0-1,000 0-1,500[b]	-0.375 to +0.525 -0.400 to +0.500	0.625 to 1.525 0.600 to 1.500	3.625 to 4.525 3.600 to 4.500
NN2	Engine regulator outlet	0-750	-0.350 to +0.550	0.650 to 1.550	3.650 to 4.550
TG3	Oxidizer turbine inlet	0-200	-0.075 to +0.825	0.925 to 1.825	3.925 to 4.825
PF5	Fuel pump balance piston cavity	0-1,000	-0.375 to +0.525	0.625 to 1.525	3.625 to 4.525
TG4	Oxidizer turbine outlet	0-100	+0.300 to +1.200	1.300 to 2.200	-- --
P07	Oxidizer pump bearing coolant[g]	0-500	-0.300 to +0.600	0.700 to 1.600	3.700 to 4.600
H01	Heat exchanger oxidizer inlet[h]	0-1,000 0-1,500[b]	-0.375 to +0.525 -0.400 to +0.500	0.625 to 1.525 0.600 to 1.500	3.625 to 4.525 3.600 to 4.500
GG1	GG chamber[i] or fuel turbine[j]	0-1,000 0-1,000	-0.375 to +0.525 -0.375 to +0.525	0.625 to 1.525 0.625 to 1.525	3.625 to 4.525 3.625 to 4.525

(a) Voltage limits on pressure parameters are based on 14.7 ±1 psia applied to the transducer during the test. Pressures outside this limit have a significant effect on the limits.
(b) Engines incorporating MD172 change.
(c) Engines incorporating MD269 or MD296 change.
(d) Engines incorporating MD282, MD313, or MD315 change.
(e) Engines incorporating MD269 change.
(f) Engines incorporating MD282, MD296, MD313, or MD315 change.
(g) Engines not incorporating MD269, MD282, MD296, MD313, or MD315 change.
(h) Engines not incorporating MD105 or MD194 change
(i) Engines not incorporating MD237 change.
(j) Engines incorporating MD237 change.

Figure 1-6. Pressure Transducer Allowable Voltage Limits (Sheet 1 of 2)

Tap Identification	Pressure Parameter	Range (psia)	Voltage Limits (vdc)[a]		
			Initial	20 Percent	80 Percent
G05	GG oxidizer injection	0-1,000	-0.375 to +0.525	0.625 to 1.525	3.625 to 4.525
		0-1,500[b]	-0.400 to +0.500	0.600 to 1.500	3.600 to 4.500
GF4	GG fuel injection	0-1,000	-0.375 to +0.525	0.625 to 1.525	3.625 to 4.525
P08	PU valve inlet	0-1,000	-0.375 to +0.525	0.625 to 1.525	3.625 to 4.525
		0-1,500[b]	-0.400 to +0.500	0.600 to 1.500	3.600 to 4.500
P09	PU valve outlet	0-500	-0.300 to +0.600	0.700 to 1.600	3.700 to 4.600
P06	Oxidizer pump primary seal cavity	0-50	+1.050 to +1.950	2.050 to 2.950	-- --
PF6	Fuel pump interstage[k] [l]	0-200	-0.075 to +0.825	0.925 to 1.825	3.925 to 4.825

(a) Voltage limits on pressure parameters are based on 14.7 ±1 psia applied to the transducer during the test. Pressures outside this limit have a significant effect on the limits.
(b) Engines incorporating MD172 change.
(k) Tap removed on engines incorporating MD233 change.
(l) Parameter deleted on engines incorporating MD304 change.

Figure 1-6. Pressure Transducer Allowable Voltage Limits (Sheet 2 of 2)

Temperature Transducer	Voltage Limits (vdc)			
	Initial Voltage	Low Calibrate	High Calibrate	High-Low Calibrate
Fuel injection CFT2	4.700 (+0.700, -0.650)	0.888 ±0.200	4.098 ±0.200	
Thrust chamber jacket No. 1 CS1	4.700 (+0.700, -0.650)	0.888 ±0.200	4.098 ±0.200	
Thrust chamber jacket No. 2 CS1a	4.700 (+0.700, -0.650)	0.888 ±0.200	4.098 ±0.200	
Oxidizer turbine outlet TGT4[a]	0.330 ±0.330	1.100 ±0.200	4.023 ±0.200	
Oxidizer turbine inlet TGT3[b]	0.279 ±0.279	1.070 ±0.200	3.860 ±0.200	
Fuel turbine inlet TGT1[b]	0.200 ±0.200	1.125 ±0.200	3.980 ±0.200	

(a) Engines not incorporating MD263 or MD355 change.
(b) Engines not incorporating MD263 change.

Figure 1-7. Temperature Transducer Allowable Voltage Limits (Sheet 1 of 2)

Temperature Transducer	Voltage Limits (vdc) Initial Voltage	Low Calibrate	High Calibrate	High-Low Calibrate
Oxidizer turbopump discharge POT3 (A- and B-sensors)	Greater than 5.000	1.075 ±0.200	3.950 ±0.200	3.505 ±0.225
Fuel turbopump discharge PFT1 (A- and B-sensors)	Greater than 5.000	0.602 ±0.200	3.615 ±0.200	1.610 ±0.300
Start tank gas TFT1 (A- and B-sensors)	4.680 ±0.720	1.120 ±0.200	4.110 ±0.200	
Helium tank gas NNT1	4.680 ±0.720	1.120 ±0.200	4.110 ±0.200	
Primary FI package	3.650 (+0.516, -0.623)	1.075 ±0.200	3.950 ±0.200	
ECA No. 1	3.650 (+0.516, -0.623)	1.075 ±0.200	3.950 ±0.200	
Auxiliary FI package	3.650 (+0.516, -0.623)	1.075 ±0.200	3.950 ±0.200	
Heat exchanger oxidizer outlet HOT2 (A- and B-sensors)(c)	2.050 (+0.400, -0.600)	1.120 ±0.200	4.075 ±0.200	
Fuel bleed valve GFT1 (A- and B-sensors)	Greater than 5.000	0.440 ±0.200	3.448 ±0.200	2.932 ±0.225
Oxidizer bleed valve GOT2 (A-sensor)(d)	Greater than 5.000	1.075 ±0.200	3.950 ±0.200	3.505 ±0.225
Oxidizer bleed valve GOT2 (B-sensor)	Greater than 5.000	1.075 ±0.200	3.950 ±0.200	3.505 ±0.225
Oxidizer turbopump bearing coolant POT4	Greater than 5.000	1.075 ±0.200	3.950 ±0.200	3.505 ±0.225
Fuel turbopump bearing PST1(d) (e)	Greater than 5.000	0.415 ±0.200	3.622 ±0.200	
ECA No. 2	3.650 (+0.516, -0.623)	1.075 ±0.200	3.950 ±0.200	

(c) Engines for SII stage.
(d) Engines not incorporating MD248 change.
(e) Engines not incorporating MD172 change.

Figure 1-7. Temperature Transducer Allowable Voltage Limits (Sheet 2 of 2)

Transducer	Input Requirements		Output Limits		
	Volts (vac peak)	Frequency (Hertz)	Volts (vac peak)	Frequency (Hertz)	Load (ohms)
Fuel turbopump speed	10 ±1	5,850 ±5	1-8	5,850 ±5	1,000
Oxidizer turbopump speed	10 ±1	2,000 ±20	1-8	2,000 ±20	1,000
Main fuel flowrate	10 ±1	200 ±20	1-5	200 ±20	3,000
Main oxidizer flowrate	10 ±1	200 ±20	1-5	200 ±20	3,000
Redundant fuel flowrate (on engines not incorporating MD150, MD280, or MD281 change)	10 ±1	200 ±20	1-5	200 ±20	3,000
Redundant oxidizer flowrate (on engines not incorporating MD150, MD280, or MD281 change)	10 ±1	200 ±20	1-5	200 ±20	3,000

Figure 1-8. Speed and Flow Transducer Function-Test Limits

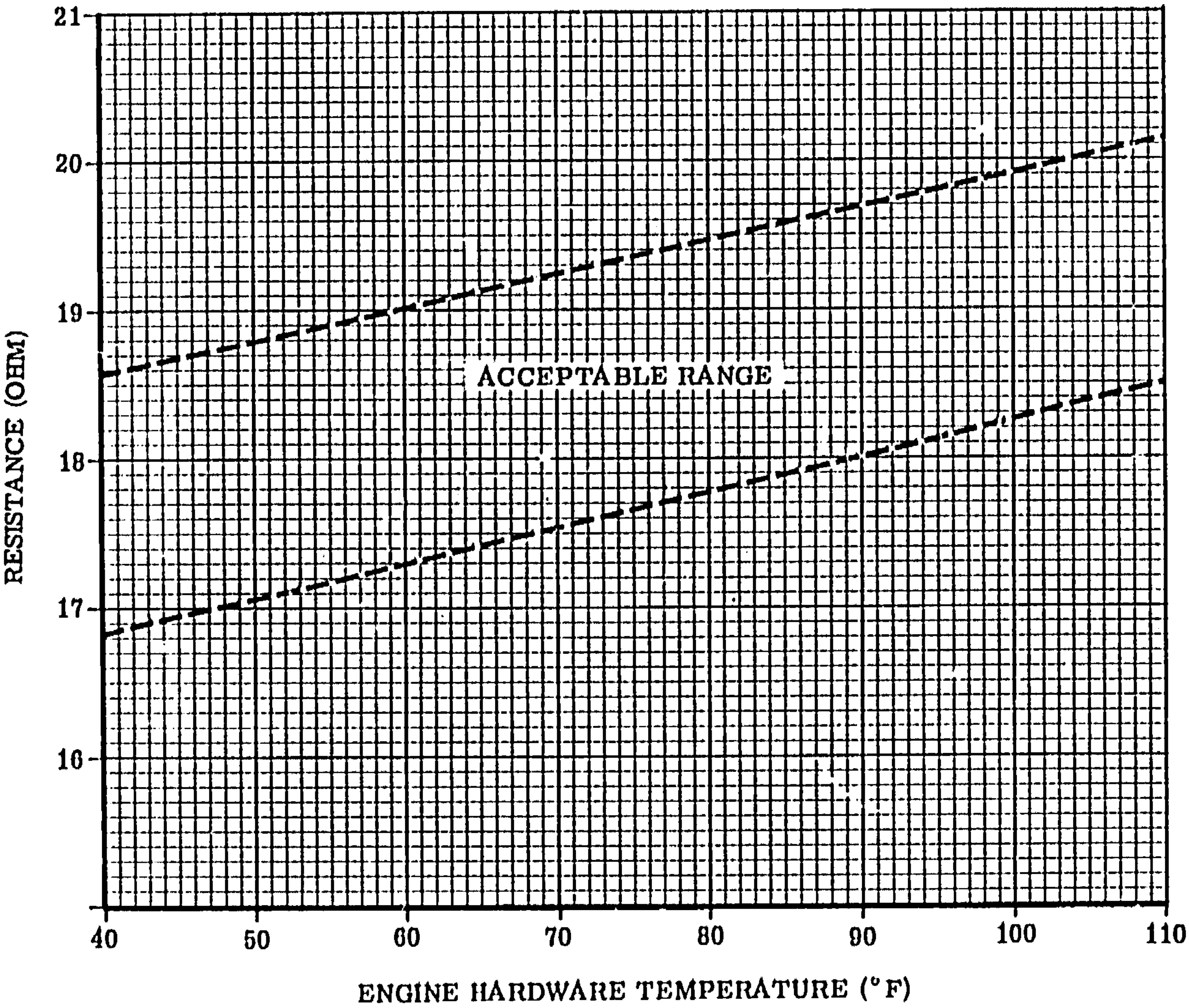


Figure 1-8A. Four-Way Valve (Ignition-Phase, Mainstage, and Start Tank Discharge) Solenoid Resistance Limits

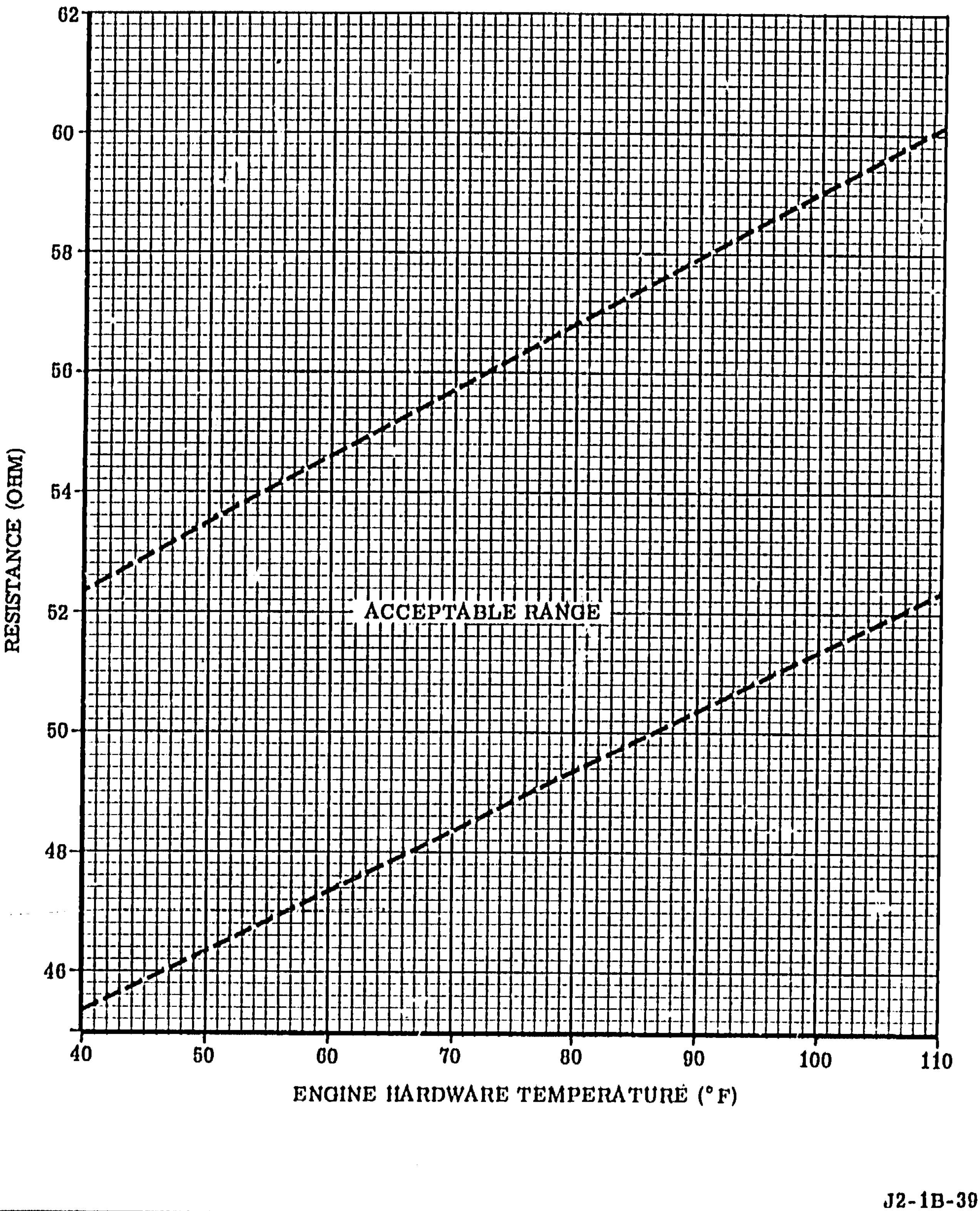


Figure 1-8B. Three-Way Valve (Helium Control, Helium Tank Emergency Vent, and Mixture Ratio Control) Solenoid Resistance Limits

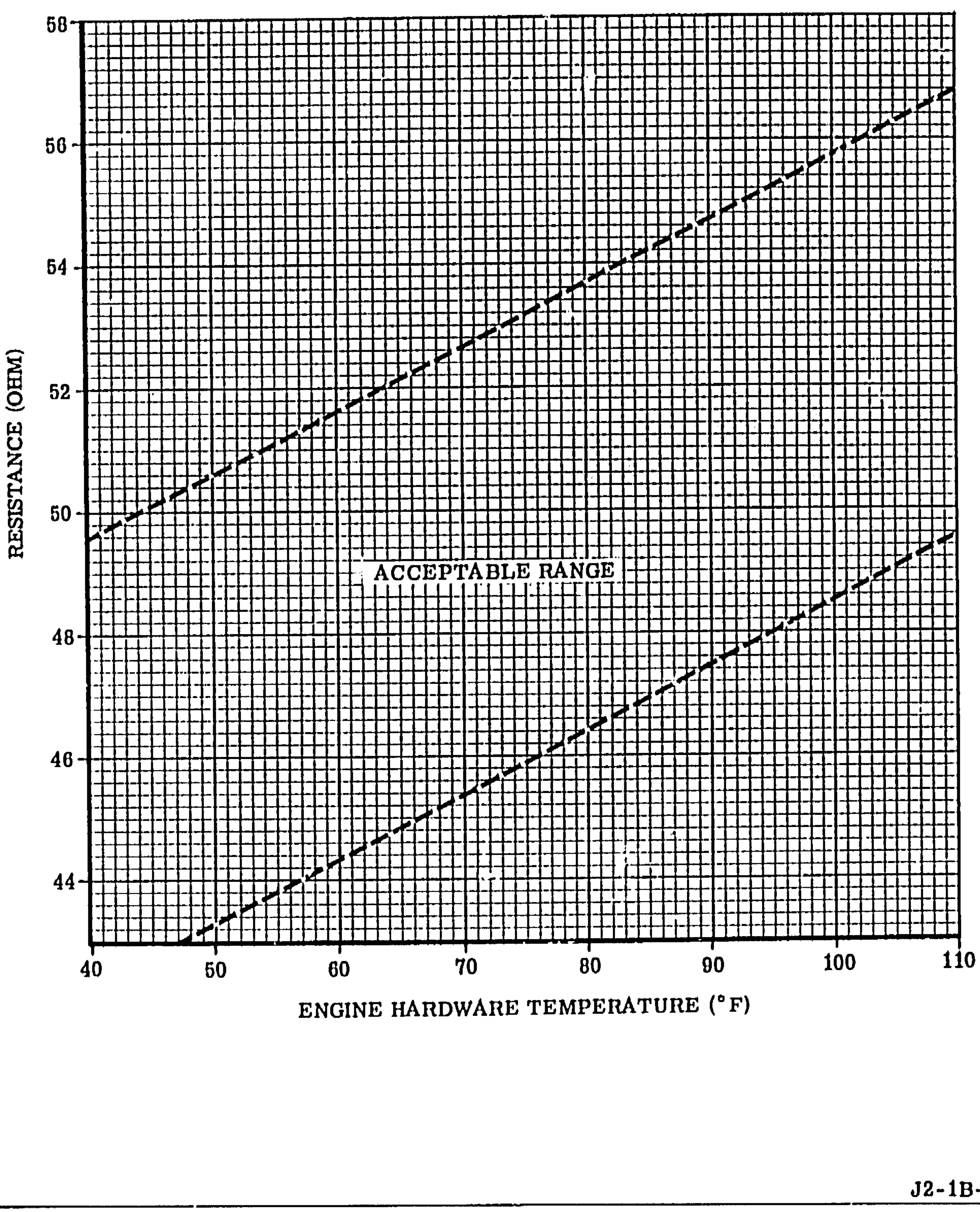


Figure 1-8C. Two-Way Valve (Start Tank Emergency Vent) Solenoid Resistance Limits

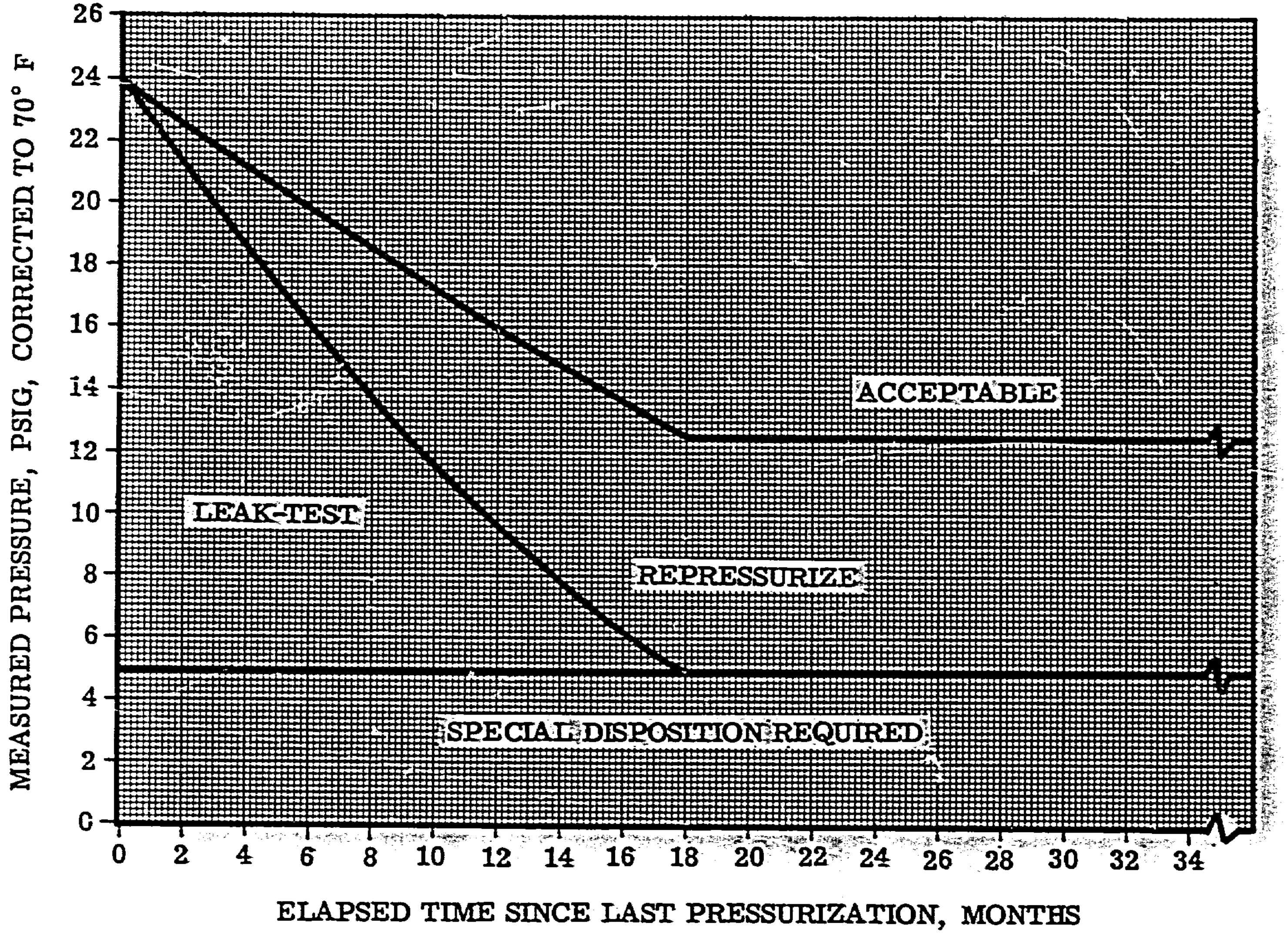


Figure 1-8D. Electrical Control Assembly and Flight Instrumentation Packages Pressure Limits

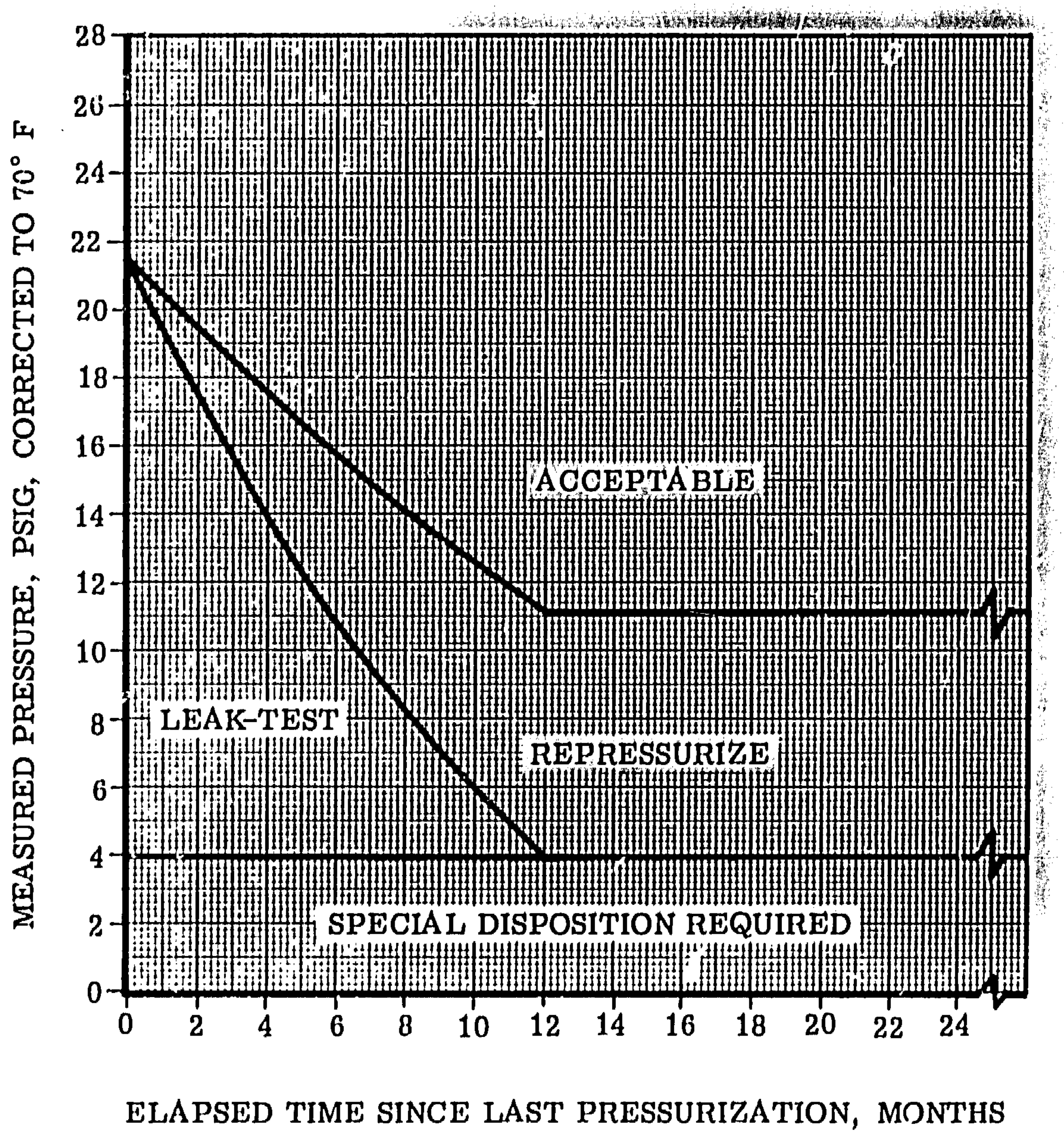


Figure 1-8E. Spark Igniter Cable Pressure Limits

Secondary Seal Helium Leakage	Primary Seal Helium Leakage: 9 scim or Less	Primary Seal Helium Leakage: Greater Than 9 scim But Less Than or Equal to 350 scim
75 scim or Less	Acceptable	Acceptable
Greater Than 75 scim But Less Than or Equal to 500 scim	Acceptable	(a)

(a) Equivalent hydrogen boattail leakage for each turbopump must be determined using measured helium leakage past both seals. Total equivalent boattail leakage for five turbopumps must not exceed 45,000 scim.

Figure 1-9. Fuel Turbopump Primary and Secondary Seal Leakage Limits for SII-Stage Engines

Secondary Seal Helium Leakage	Primary Seal Helium Leakage: 10 scim or Less	Primary Seal Helium Leakage: Greater Than 10 scim But Less Than or Equal to 350 scim
110 scim or Less	Acceptable	Acceptable
Greater Than 110 scim But Less Than or Equal to 500 scim	Acceptable	Not Acceptable

Figure 1-10. Fuel Turbopump Primary and Secondary Seal Leakage Limits for SIVB-Stage Engines

Phase	Valve	Control Signal to Valve Motion Start (Milliseconds)	Valve Motion (Milliseconds)
Ignition	ASI valve (open)	---	Fully open within 100 milliseconds after engine start signal.
	Fuel and oxidizer bleed valves (close)[a]	---	Fully closed within 120 milliseconds after engine start signal.
	Fuel and oxidizer bleed valves (close)[b]	---	Fully closed within 200 milliseconds after engine start signal.
	MFV (open)[a]	60 ±30	80 ±50
	MFV (open)[b]	60 ±30	110 ±60
	STDV (open)	100 ±20	105 ±20
	MRCV (open)[p]	220 ±100[r]	175 ±100
	MRCV (open)[q]	320 ±100[r]	130 ±75
Mainstage	GG valve (oxidizer side) (open)[c]	140 ±10	50 ±30
	STDV (close)[d]	95 ±20	250 ±40
	STDV (close)[e]	120 ±20	215 ±40
	MOV (open)[g]		
	First stage	50 ±20	50 ±25[f]
	Second stage	465 ±75	1,390 ±40
	MOV (open)[h]		
	First stage	50 ±20	50 ±25[f]
	Second stage	610 ±70	1,825 ±75[n]
	MOV (open)[i]		
	First stage	50 ±20	50 ±25[f]
	Second stage	560 ±70	1,675 ±25[o]

(a) Engines not incorporating MD333 change.
(b) Engines incorporating MD333 change.
(c) Plateau during opening must occur at 50% ±15% of indicated valve opening travel.
(d) On engines not incorporating MD275 change and on which STDV 304386 has not been installed as a spare.
(e) On engines incorporating MD275 change or on which STDV 304386 has been installed as a spare.
(f) First-stage travel must be 14 ±2 degrees of valve opening.
(g) Engines incorporating MD221 change.
(h) Engines incorporating MD214 or MD172 change but not incorporating MD265 change.
(i) Engines incorporating MD265 change; these MOV times must not be used on engines that will subsequently be static tested at sea-level conditions.
(n) The point determined by MOV second-stage ramp time (milliseconds) and thermostatic orifice flow (scfm) must be within envelope of figure 1-12.
(o) Refer to Engine Log Book and obtain all MOV opening times since installation of control orifice. The average valve time obtained from Engine Log Book information and sequence test being run must be within envelope of figure 1-12 for engines incorporating MD265 change.
(p) Engines incorporating MD371 change.
(q) Engines incorporating MD366 change.
(r) Measured from helium control valve energize signal.

Figure 1-11. Valve Operating Time Limits (Sheet 1 of 2)

Phase	Valve	Control Signal to Valve Motion Start (Milliseconds)	Valve Motion (Milliseconds)
Mainstage (cont)	OTBV (close)	(j)	(j)
	MRCV (close)(p)	330 ±100(s)	270 ±100
	MRCV (close)(q)	315 ±100(s)	120 ±75
	MRCV (open)(p)	110 ±75(s)	175 ±100
	MRCV (open)(q)	185 ±100(s)	130 ±75
Cutoff	OTBV (open)	---	Fully open within 10.0 seconds after engine cutoff signal.
	MOV (close)	60 ±15	120 ±15
	MFV (close)	90 ±25	225 ±25
	GG valve (oxidizer side) (close)(k)	125 (+35, -45)	35 (+20, -25)
	GG valve (oxidizer side) (close)(l)	75 (+25, -35)	35 (+20, -25)
	GG valve (fuel side) (close)	---	(m)
	ASI valve (close)	---	ASI valve open signal must drop out within 100 milliseconds after engine cutoff signal.
	Fuel and oxidizer bleed valves (open)	---	Bleed valve closed signals must drop out within 30 seconds after engine cutoff signal.
	MRCV (close)(p)(q)	---	Closed within 15 seconds after engine cutoff signal or 14 seconds after helium control valve deenergized.

(j) Total time from mainstage control valve to 80% of indicated valve travel must be 400 (+160, -50) milliseconds, but valve must be fully closed within 5 seconds after mainstage control signal.
(k) On engines not incorporating MD154 change and where fast-shutdown valve 557817-11 or 558127-11 has not been installed as a spare.
(l) On engines incorporating MD154 change or where fast-shutdown valve 557817-11 or 558127-11 has been installed as spare.
(m) Valve fuel poppet must be fully closed within 500 milliseconds after cutoff signal but must not close within 10 milliseconds after oxidizer poppet reaches fully closed position.
(p) Engines incorporating MD371 change.
(q) Engines incorporating MD366 change.
(s) Measured from MRCV control signal.

Figure 1-11. Valve Operating Time Limits (Sheet 2 of 2)

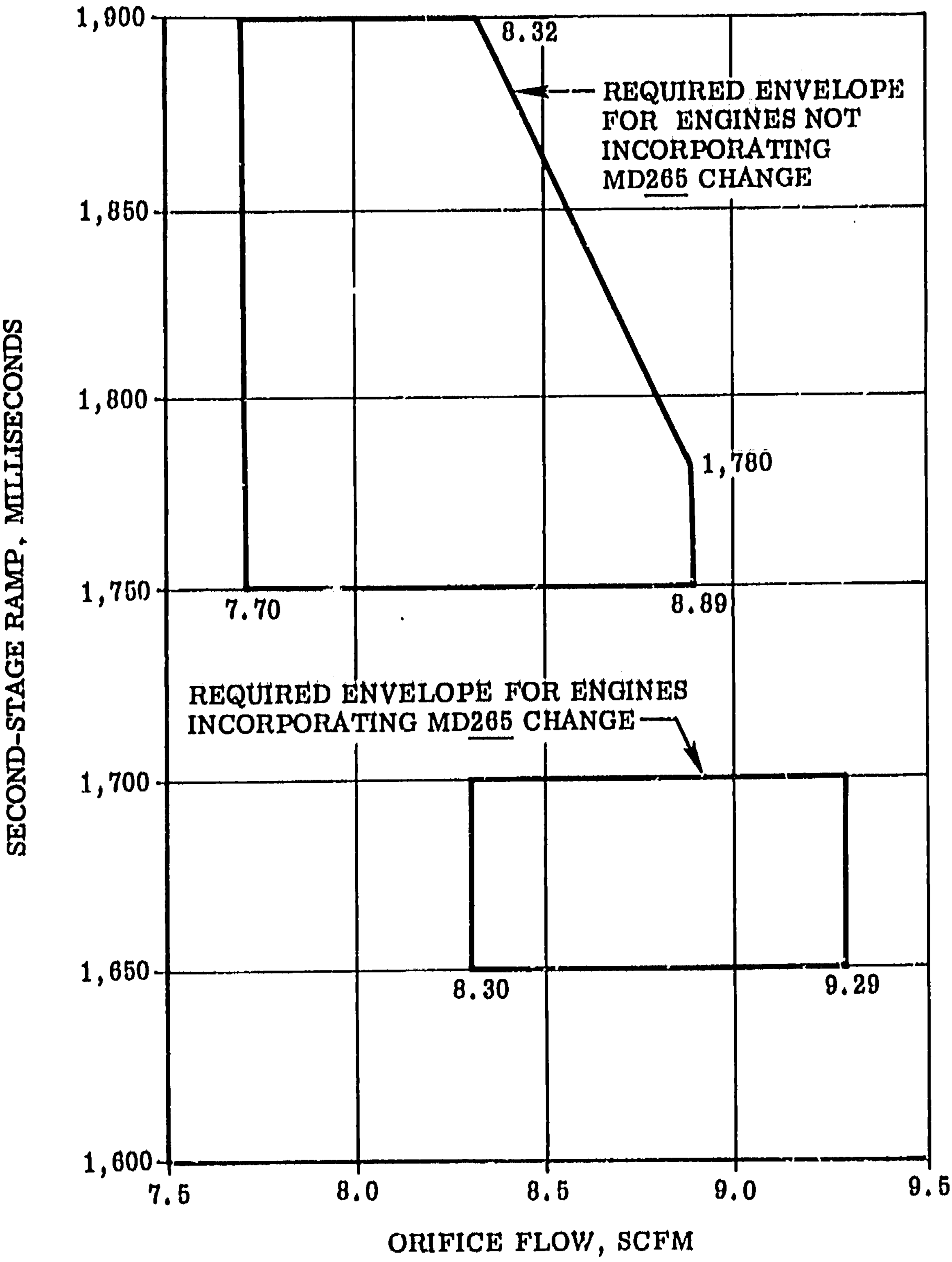


Figure 1-12. Main Oxidizer Valve Second-Stage Ramp Time Versus Orifice Flow (Required Envelope)

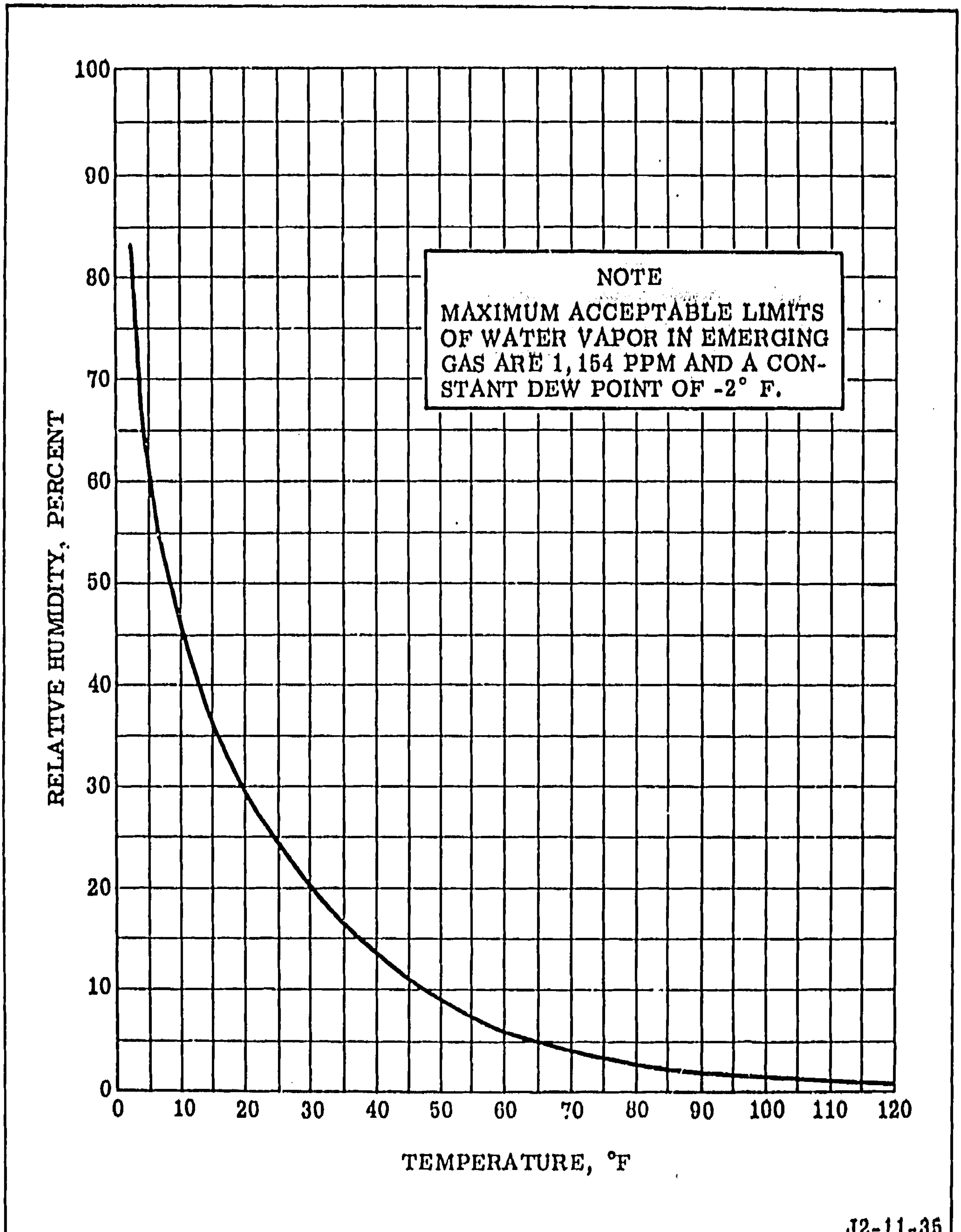


Figure 1-13. Engine Drying Limits

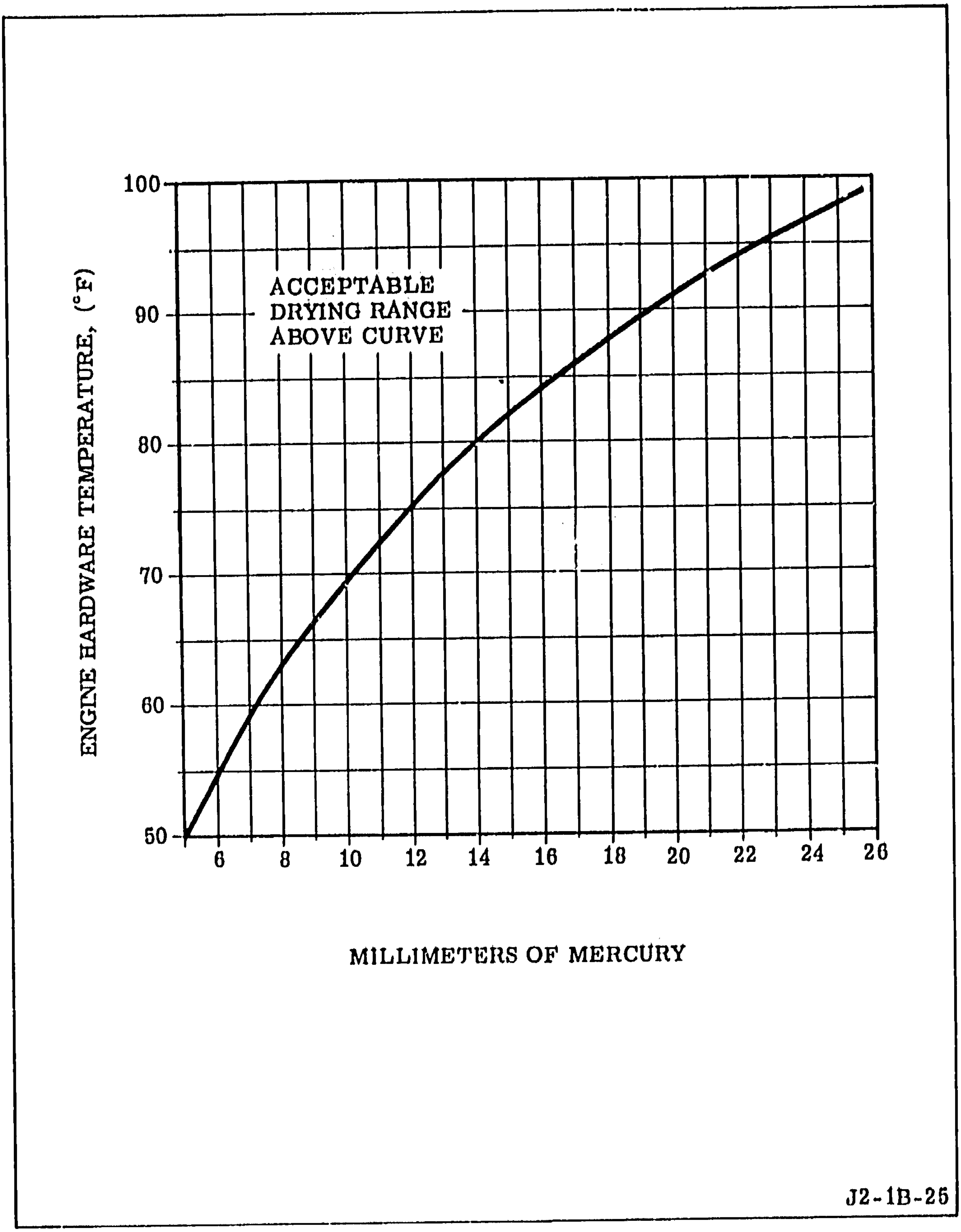


Figure 1-14. Hardware Temperature Versus Required Absolute Pressure

SECTION II

GENERAL REQUIREMENTS

SCOPE. This section contains general requirements that support the authorized activities outlined in section I. These include engine fluid input, environmental, maintenance, operational, and documentation requirements.

2.1 FLUID REQUIREMENTS.

2.1.1 The fluid requirement acceptability for the J-2 engine interface is as specified in paragraphs 2.1.2 through 2.1.10 and as delineated in J-2 Engine Model Specification R-2158bS.

2.1.2 PRESSURIZING AGENT REQUIREMENTS.

2.1.2.1 Gaseous Hydrogen.

a. Fluid specification: gaseous hydrogen (MIL-P-27201).

b. Fluid temperature: chilled to meet start tank temperature conditions of paragraph 2.1.7.

c. Fluid cleanness: Gaseous hydrogen must be cooled to -250° F then passed through a filtration system equipped with a 10-micron nominal, 50-micron absolute, rated filter.

2.1.2.2 Helium.

a. Fluid specification: Helium (Bureau of Mines, Grade A).

b. Fluid moisture content: Helium must have a moisture content less than that defined by a dewpoint of -80° F at standard atmospheric pressure.

c. Fluid cleanness: Helium must be supplied from a loading system equipped with a 10-micron nominal, 50-micron absolute, rated filter.

2.1.2.3 Gaseous Nitrogen.

a. Fluid specification: gaseous nitrogen (MIL-P-27401).

b. Fluid hydrocarbon content: Gaseous nitrogen total hydrocarbon content must not exceed 10 ppm.

c. Fluid cleanness: Gaseous nitrogen must be supplied from a system equipped with a 10-micron nominal, 50-micron absolute, rated filter.

2.1.3 PURGE REQUIREMENTS.

2.1.3.1 Engine Purge Requirements for Static-Testing SIVB Stage. The purge gas must be supplied to the engine at temperatures, pressures, flowrates, and sequence outlined in figure 2-1.

2.1.3.2 Engine Purge Requirements for Static-Testing SII Stage. The purge gas must be supplied to the engine at temperatures, pressures, flowrates, and sequence outlined in figure 2-2.

2.1.3.3 Engine Purge Requirements for Static-Testing SII Stage (Alternate). These requirements are applicable when the oxidizer dome purge through instrumentation port CO3a is used. The purge gas must be supplied to the engine at temperatures, pressures, flowrates, and sequence outlined in figure 2-3.

2.1.3.4 Engine Purge Requirements for Flight (SIVB and SII Stages). The purge gas must be supplied to the engine at temperatures, pressures, flowrates, and sequence outlined in figure 2-4.

2.1.3.5 Helium Tank Purge Requirements. The engine purges of paragraphs 2.1.3.1 through 2.1.3.4 satisfy the requirements of this purge. If the helium tank is purged independently, the following requirements must be met:

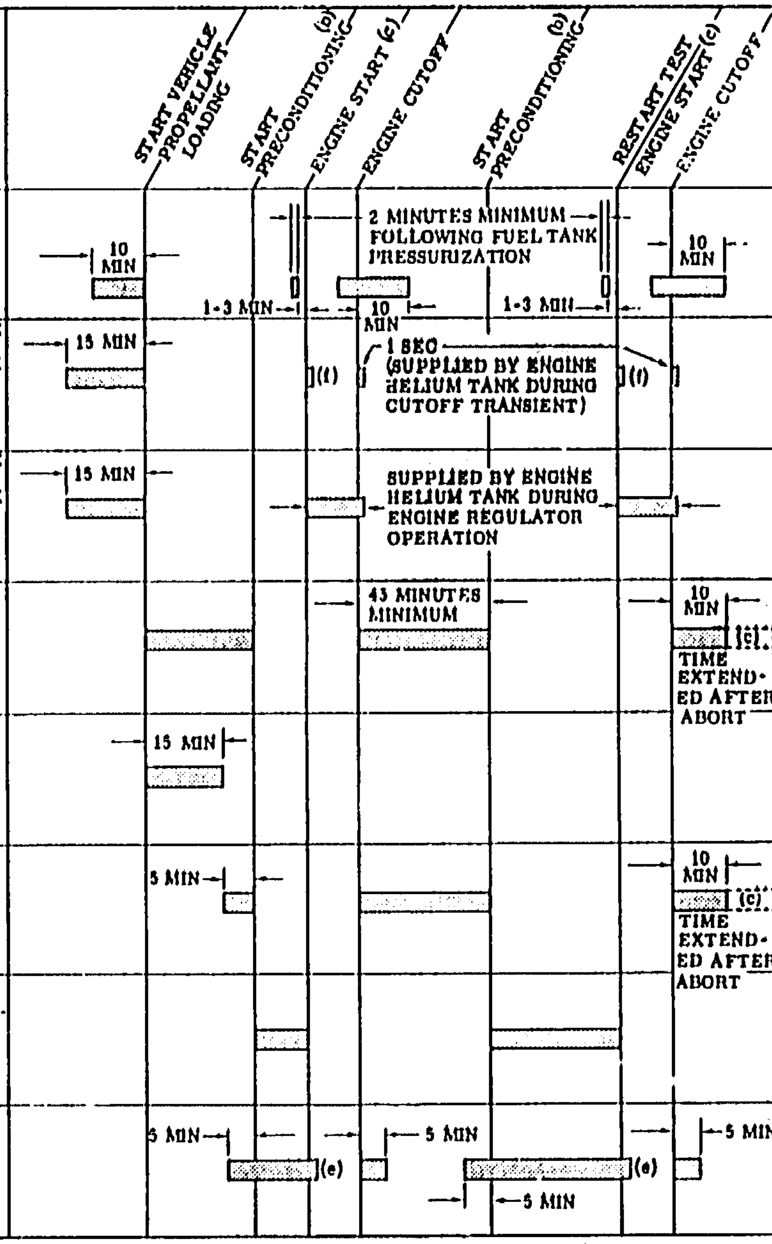
a. Media: helium conforming to requirements of paragraph 2.1.2.2.

b. Pressure: 1,500 psia maximum as measured in the tank.

c. Temperature: ambient.

d. Duration: Purge, as required, to reduce oxygen content in tank to one percent or less.

PURGE	PURGE PARAMETERS
TURBOPUMP AND GAS GENERATOR (PURGE MANIFOLD SYSTEM)	HELIUM, 82-130 PSIA, 50° TO 200° F AT CUSTOMER CONNECT PANEL (6 SCFM REFERENCE)(a)
OXIDIZER DOME AND GAS GENERATOR OXIDIZER INJECTOR (ENGINE PNEUMATIC SYSTEM)	HELIUM CONTROL VALVE ENERGIZED AND HELIUM AT ENGINE HELIUM TANK FILL CUSTOMER CONNECT, 600 PSIA MINIMUM, 50 TO 200 F (230 SCFM REFERENCE)
OXIDIZER TURBOPUMP INTERMEDIATE SEAL CAVITY (ENGINE PNEUMATIC SYSTEM)	HELIUM CONTROL VALVE ENERGIZED AND HELIUM AT ENGINE HELIUM TANK FILL CUSTOMER CONNECT, 600 PSIA MINIMUM, 50 TO 200 F (2,600 - 7,000 SCIM REF)
OXIDIZER DOME (FACILITY LINE TO INSTRUMENTATION PORT CO3a)(d)	NITROGEN, 415-675 PSIA, 100° TO 200° F AT DOME DIFFUSER INLET (175-230 SCFM REFERENCE)
THRUST CHAMBER JACKET (PURGE AND PRECONDITIONING THROUGH CUSTOMER CONNECT LINE)	HELIUM, 200 PSIA MAXIMUM, 50° TO 200° F AT CUSTOMER CONNECT PANEL (80 SCFM MINIMUM)
	HELIUM, 27-29 PSIA, 50° TO 200° F AT CUSTOMER CONNECT PANEL (35 SCFM REFERENCE)
	HELIUM, 1,000 PSIA MAXIMUM, -420° TO -300° F AT CUSTOMER CONNECT PANEL, 10-25 LB/MIN
THRUST CHAMBER DIFFUSER (FACILITY LINE)	NITROGEN, 40° F MINIMUM AT DIFFUSER INLET, 0.1 LB/SEC MINIMUM



(a) TURBOPUMP AND GAS GENERATOR FUEL INJECTOR PURGE IS REQUIRED AT OPERATING PRESSURE AT CUSTOMER CONNECT PANEL WITHIN 0.2 SECOND OF ENGINE CUTOFF. PURGE MAY BE TURNED ON ANYTIME DURING MAINSTAGE OPERATION. IF TIME REQUIRED TO ATTAIN PURGE OPERATING PRESSURE IS GREATER THAN 0.2 SECOND, DRY TURBOPUMP SEAL CAVITIES AND GG FUEL MANIFOLD SYSTEM OR INCREASE PURGE TEMPERATURE TO 100° TO 200 F AND CONTINUE PURGE FOR A MINIMUM OF 2 HOURS PRIOR TO ANY SUBSEQUENT TEST.

(b) ABORT PRIOR TO ENGINE START. IF NECESSARY TO TERMINATE PRECONDITIONING PRIOR TO ENGINE START, THE 27-29 PSIA HELIUM THRUST CHAMBER JACKET PURGE AND 415-675 PSIA NITROGEN OXIDIZER DOME PURGE (CO3a) MUST BE INITIATED AND CONTINUED UNTIL PRECONDITIONING IS RESTARTED.

(c) ABORT AFTER ENGINE START. AN INSPECTION MUST BE MADE OF MAIN INJECTOR HARDWARE TO MAKE SURE THAT INJECTOR HARDWARE IS FREE OF FROST AND MOISTURE. IF THIS CANNOT BE DONE, A 10-MINUTE TURBOPUMP AND GAS GENERATOR PURGE AND A 45-MINUTE OXIDIZER DOME (CO3a) AND THRUST CHAMBER JACKET PURGE AT 27-29 PSIA SHOULD BE USED PRIOR TO STARTING PRECONDITIONING.

(d) PURGE DIFFUSER KIT 9019975 MUST BE USED.

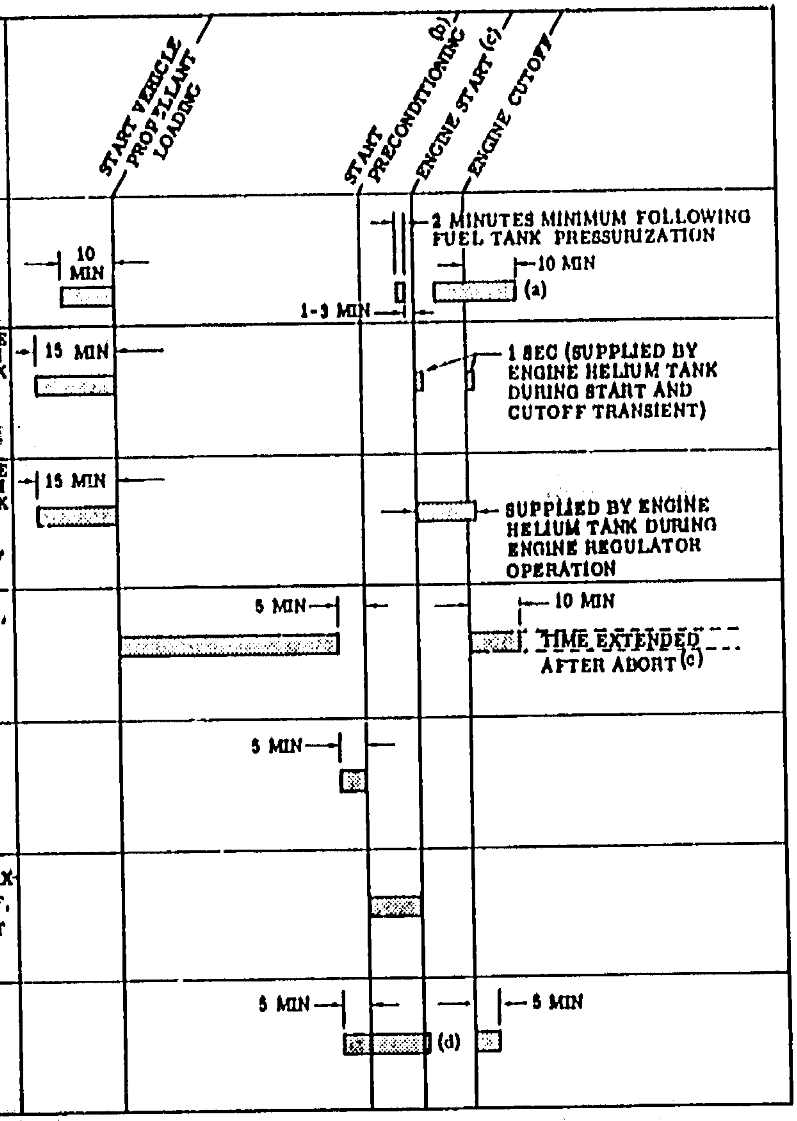
(e) DIFFUSER WATER FLOW ON, NOT MORE THAN 5 SECONDS BUT NOT LESS THAN 3 SECONDS PRIOR TO TRUE ENGINE START. PURGE OFF AT ENGINE START SIGNAL WITH A 1-2 SECOND PURGE OVERLAP OF COOLANT.

(f) PURGE ON FOR DURATION OF FUEL LEAD.

J2-11-13A

Figure 2-1. Engine Purge Requirements for Static-Testing SIVB Stage

PURGE	PURGE PARAMETERS
TURBOPUMP AND GAS GENERATOR (PURGE MANIFOLD SYSTEM)	HELIUM, 82-130 PSIA, 50° TO 200° F, AT CUSTOMER CONNECT PANEL (6 SCFM REFERENCE)(a)
OXIDIZER DOME AND GAS GENERATOR OXIDIZER INJECTOR (ENGINE PNEUMATIC SYSTEM)	HELIUM CONTROL VALVE ENERGIZED AND HELIUM AT ENGINE HELIUM TANK FILL CUSTOMER CONNECT, 600 PSIA MINIMUM, 60° to 200° F (230 SCFM REFERENCE)
OXIDIZER TURBOPUMP INTERMEDIATE SEAL CAVITY (ENGINE PNEUMATIC SYSTEM)	HELIUM CONTROL VALVE ENERGIZED AND HELIUM AT ENGINE HELIUM TANK FILL CUSTOMER CONNECT, 600 PSIA MINIMUM, 50° TO 200° F (2,600 - 7,000 SCIM REF)
THRUST CHAMBER JACKET (PURGE AND PRECONDITIONING THROUGH CUSTOMER CONNECT LINE)	NITROGEN, 165-215 PSIA, 100° TO 200° F, AT CUSTOMER CONNECT PANEL (100 SCFM REFERENCE)
	HELIUM, 200 PSIA MAXIMUM, AMBIENT TEMPERATURE, AT CUSTOMER CONNECT PANEL (60 SCFM MINIMUM)
	HELIUM, 1,000 PSIA MAXIMUM, -420° TO -300° F, AT CUSTOMER CONNECT PANEL, 10-25 LB/MIN
THRUST CHAMBER DIFFUSER (FACILITY LINE)	NITROGEN, 40° F MINIMUM AT DIFFUSER INLET, 0.1 LB/SEC MINIMUM



(a) TURBOPUMP AND GAS GENERATOR FUEL INJECTOR PURGE IS REQUIRED AT OPERATING PRESSURE AT CUSTOMER CONNECT PANEL WITHIN 0.2 SECOND OF ENGINE CUTOFF. PURGE MAY BE TURNED ON ANYTIME DURING MAINSTAGE OPERATION. IF TIME REQUIRED TO ATTAIN PURGE OPERATING PRESSURE IS GREATER THAN 0.2 SECOND, DRY TURBOPUMP SEAL CAVITIES AND GG FUEL MANIFOLD SYSTEM OR INCREASE PURGE TEMPERATURE TO 100° TO 200° F AND CONTINUE PURGE FOR A MINIMUM OF 2 HOURS PRIOR TO ANY SUBSEQUENT TEST.

(b) ABORT PRIOR TO ENGINE START; IF NECESSARY TO TERMINATE PRECONDITIONING PRIOR TO ENGINE START, THE 200-PSIA HELIUM THRUST CHAMBER JACKET PURGE SHOULD BE USED UNTIL PRECONDITIONING IS AGAIN INITIATED, OR THE HELIUM THRUST CHAMBER JACKET PURGE SHOULD BE USED FOR A MINIMUM OF 5 MINUTES AND IMMEDIATELY FOLLOWED BY THE 165-215 PSIA NITROGEN THRUST CHAMBER JACKET PURGE UNTIL THE 200-PSIA THRUST CHAMBER HELIUM PURGE IS REINSTITUTED PRIOR TO PRECONDITIONING.

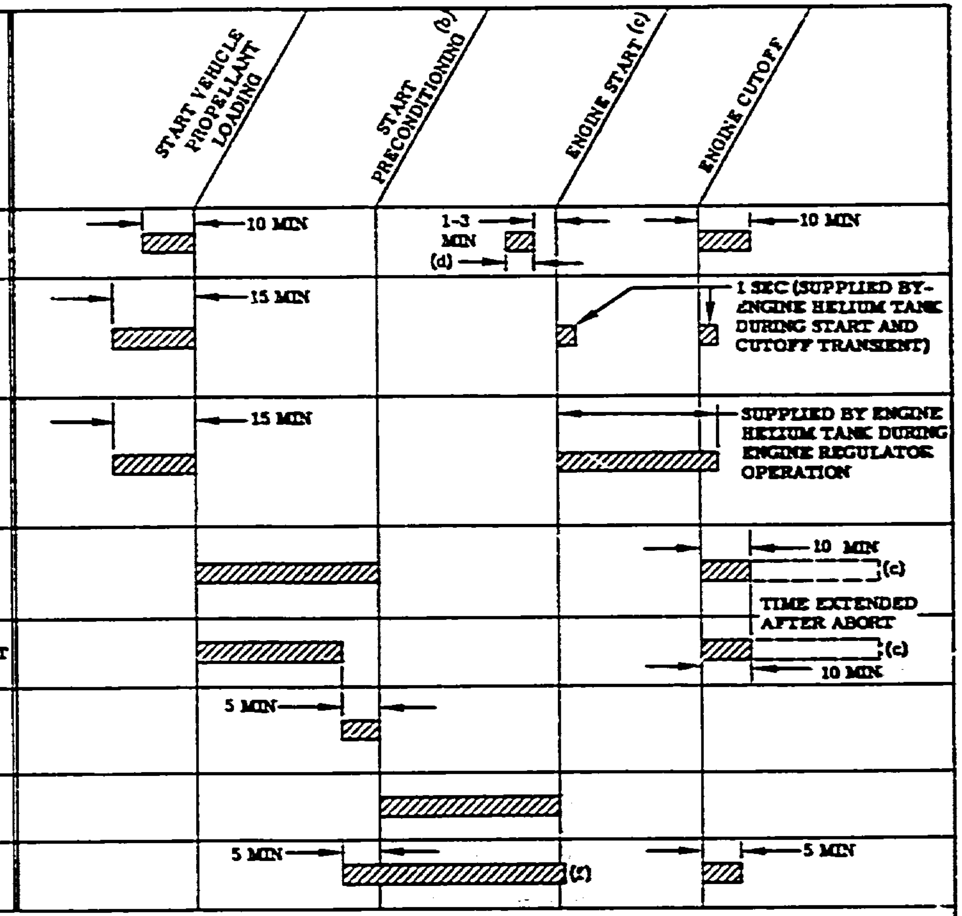
(c) ABORT AFTER ENGINE START; IMMEDIATELY PRIOR TO INITIATING PURGE PROCEDURES FOR SUBSEQUENT TEST, INSPECTION OF MAIN INJECTOR HARDWARE MUST BE MADE TO MAKE SURE INJECTOR HARDWARE IS FREE OF FROST AND MOISTURE. (NITROGEN THRUST CHAMBER JACKET PURGE OF 215-265 PSIA, 100° TO 200° F, 130 SCFM REFERENCE, SHOULD BE SUFFICIENT.) UPON SATISFACTORY INSPECTION OF INJECTOR, PREPROPELLANT LOADING PURGES SHOULD BE INITIATED AND NORMAL PURGE PROCEDURE FOLLOWED.

(d) DIFFUSER WATER FLOW ON, NOT MORE THAN 5 SECONDS BUT NOT LESS THAN 3 SECONDS PRIOR TO TRUE ENGINE START. PURGE OFF AT ENGINE START SIGNAL WITH A 1-2 SECOND PURGE OVERLAP OF COOLANT.

J2-11-14

Figure 2-2. Engine Purge Requirements for Static-Testing SII Stage

PURGE	PURGE PARAMETERS
TURBOPUMP AND GAS GENERATOR (PURGE MANIFOLD SYSTEM)	HELIUM, 85-130 PSIA, 50° TO 200° F, AT CUSTOMER CONNECT PANEL (6 SCFM REFERENCE)(a)
OXIDIZER DOME AND GAS GENERATOR OXIDIZER INJECTOR (ENGINE PNEUMATIC SYSTEM)	HELIUM CONTROL VALVE ENERGIZED AND HELIUM AT ENGINE HELIUM TANK FILL CUSTOMER CONNECT, 600 PSIA MINIMUM, 50° to 200° F (230 SCFM REFERENCE)
OXIDIZER TURBOPUMP INTERMEDIATE SEAL CAVITY (ENGINE PNEUMATIC SYSTEM)	HELIUM CONTROL VALVE ENERGIZED AND HELIUM AT ENGINE HELIUM TANK FILL CUSTOMER CONNECT, 600 PSIA MINIMUM, 50° to 200° F (2,600-7,000 SCIM REFERENCE)
OXIDIZER DOME (FACILITY LINE TO INSTRUMENTATION PORT CO3a)(e)	NITROGEN, 415-675 PSIA, 100° TO 200° F AT DOME DIFFUSER INLET (175-230 SCFM REFERENCE)
THRUST CHAMBER JACKET (PURGE AND PRECONDITIONING THROUGH CUSTOMER CONNECT LINE)	NITROGEN, 165-215 PSIA, 100° TO 200° F AT CUSTOMER CONNECT PANEL (100 SCFM REFERENCE)
	HELIUM, 200 PSIA MAXIMUM, AMBIENT TEMPERATURE AT CUSTOMER CONNECT PANEL (80 SCFM MINIMUM)
	HELIUM, 1,000 PSIA MAXIMUM, -420° TO -300° F AT CUSTOMER CONNECT PANEL, 10-25 LB/MIN
THRUST CHAMBER DIFFUSER (FACILITY LINE)	NITROGEN, 40° F MINIMUM AT DIFFUSER INLET, 0.1 LB/SEC MINIMUM



(a) TURBOPUMP AND GG FUEL INJECTOR PURGE IS REQUIRED AT OPERATING PRESSURE AT CUSTOMER CONNECT PANEL WITHIN 0.2 SECOND OF ENGINE CUTOFF. PURGE MAY BE TURNED ON ANYTIME DURING MAINSTAGE OPERATION. IF TIME REQUIRED TO ATTAIN PURGE OPERATING PRESSURE IS GREATER THAN 0.2 SECOND, DRY TURBOPUMP SEAL CAVITIES AND GG FUEL MANIFOLD SYSTEM OR INCREASE PURGE TEMPERATURE TO 100° TO 200° F AND CONTINUE PURGE FOR A MINIMUM OF 2 HOURS PRIOR TO ANY SUBSEQUENT TEST.

(b) ABORT PRIOR TO ENGINE START. IF NECESSARY TO TERMINATE PRECONDITIONING PRIOR TO ENGINE START, THE 200-PSIA HELIUM THRUST CHAMBER JACKET PURGE SHOULD BE USED UNTIL PRECONDITIONING IS AGAIN INITIATED; OR THE HELIUM THRUST CHAMBER JACKET PURGE SHOULD BE USED FOR A MINIMUM OF 5 MINUTES AND IMMEDIATELY FOLLOWED BY THE 165-215 PSIA NITROGEN THRUST CHAMBER PURGE UNTIL THE 200-PSIA THRUST CHAMBER HELIUM PURGE IS REINSTITUTED PRIOR TO PRECONDITIONING.

(c) ABORT AFTER ENGINE START. AN INSPECTION MUST BE MADE OF MAIN INJECTOR HARDWARE TO MAKE SURE THAT INJECTOR HARDWARE IS FREE OF FROST AND MOISTURE. IF THIS CANNOT BE DONE, PERFORM A 10-MINUTE TURBOPUMP AND GG PURGE AND A 45-MINUTE OXIDIZER DOME (CO3a) AND THRUST CHAMBER JACKET PURGE WITH 165-215 PSIA, 100° TO 200° F NITROGEN.

(d) TWO MINUTES MINIMUM FOLLOWING FUEL TANK PRESSURIZATION.

(e) PURGE DIFFUSER KIT 9019975 MUST BE USED.

(f) DIFFUSER WATER FLOW ON NOT MORE THAN 5 SECONDS BUT NOT LESS THAN 3 SECONDS PRIOR TO TRUE ENGINE START. PURGE OFF AT ENGINE START SIGNAL WITH A 1-2 SECOND PURGE OVERLAP OF COOLANT.

J2-11-15

Figure 2-3. Engine Purge Requirements for Static-Testing SII Stage (Alternate)

PURGE	PURGE PARAMETER	START VEHICLE PROPELLANT LOADING	START PRECONDITIONING	LIFTOFF	ENGINE START	ENGINE CUTOFF	SIVB/SV ENGINE RESTART	ENGINE CUTOFF	
NITROGEN BOATTAIL									
TURBOPUMP AND GAS GENERATOR	HELIUM, 82-130 PSIA, 50° TO 200° F AT CUSTOMER CONNECT PANEL (6 SCFM REFERENCE)		10 MIN			(a)	10 MIN		
OXIDIZER DOME AND GAS GENERATOR OXIDIZER INJECTOR	HELIUM CONTROL VALVE ENERGIZED AND HELIUM AT ENGINE HELIUM TANK FILL CUSTOMER CONNECT, 600 PSIA MINIMUM, 50° TO 200° F (230 SCFM REFERENCE)		15 MIN			(d)	SUPPLIED BY ENGINE HELIUM TANK DURING CUTOFF TRANSIENT	(d)	
OXIDIZER TURBOPUMP INTERMEDIATE SEAL CAVITY	HELIUM CONTROL VALVE ENERGIZED AND HELIUM AT ENGINE HELIUM TANK CUSTOMER CONNECT, 600 PSIA MINIMUM, 50° TO 200° F (2,600 TO 7,000 SCIM REFERENCE)		15 MIN				SUPPLIED BY ENGINE HELIUM TANK DURING ENGINE REGULATOR OPERATION		
THRUST CHAMBER JACKET	HELIUM, 200 PSIA, MAXIMUM, (b) 50° TO 200° F AT CUSTOMER CONNECT PANEL (80 SCFM MINIMUM)			15 MIN					
	HELIUM, 200 PSIA MAXIMUM, AMBIENT TEMPERATURE AT CUSTOMER CONNECT PANEL (80 SCFM MINIMUM)			5 MIN					
	HELIUM, 1,000 PSIA MAXIMUM, (c) -420° TO -300° F AT CUSTOMER CONNECT PANEL, 10-25 LB/MINUTE								

(a) SIVB/SV REQUIRES THIS PURGE TO BE TURNED ON FOR 10 MINUTES AT CUTOFF OF ENGINE FIRST BURN. PURGE IS REQUIRED TO BE AT OPERATING PRESSURE AT THE CUSTOMER CONNECT PANEL WITHIN 0.2 SECOND OF ENGINE CUTOFF. IF ENGINE PURGE PRESSURE CANNOT BE OBTAINED WITHIN THIS TIME, THE PURGE MAY BE TURNED ON ANYTIME DURING MAINSTAGE OPERATION. A PURGE TEMPERATURE REQUIREMENT OF BETWEEN -40° AND +200° F EXISTS AT THIS TIME.

(b) THIS THRUST CHAMBER JACKET PURGE MUST BE ACTIVATED DURING ANY TIME INTERVAL SUBSEQUENT TO PROPELLANT LOADING THAT THE VEHICLE NITROGEN BOATTAIL PURGE IS NOT IN OPERATION.

(c) IF PRECONDITIONING IS PREMATURELY TERMINATED BEFORE BOOSTER IGNITION THRUST CHAMBER JACKET AMBIENT HELIUM PURGE MUST BE TURNED ON. THRUST CHAMBER PRE-CHILL MUST BE REACTIVATED 7-1/2 MINUTES BEFORE BOOSTER IGNITION.

(d) PURGE IS ON FOR DURATION OF FUEL LEAD

J2-11-45C

Figure 2-4. Engine Purge Requirements for Flight (SIVB and SII Stages)

2.1.3.6 Start Tank Purge and Leak-Test Requirements.

a. Media: gaseous hydrogen or helium conforming to specification, cleanness, and moisture content requirements of paragraph 2.1.2.1 or 2.1.2.2.

b. Pressure: 500 psia maximum as measured in tank.

c. Temperature: ambient.

d. Pressurization rate: See figure 2-12 for start tank maximum pressurization rate.

e. Purge, as required, to reduce oxygen content in tank to one percent or less.

f. If the start tank facility supply has oscillatory pressure transients, the following relationship must be met:

$$f_1 x a \leq 20.0 + 0.022 P_B$$

where

f = frequency of oscillations in supply system, Hz
a = peak-to-peak amplitude of oscillations in supply system, psi
P_B = start tank pressure, psia
f_1 = (for $f \leq 1.0$ Hz)
f_1 = 1.0 (for $f > 1.0$ Hz)

2.1.3.7 Purge Requirements for Engine Temperature Conditions Below 35° F. If the thrust chamber temperature monitored at the main fuel injection temperature transducer (CFT2) is at or below 35° F, the purges outlined in figures 2-1 through 2-4 do not provide proper removal of moisture from the thrust chamber injector area. If this temperature is at or below 35° F before initiating pre-propellant loading purges, perform the following procedure before loading vehicle propellants:

a. Initiate oxidizer dome and GG oxidizer injector helium purge at temperatures and pressures outlined in figures 2-1 through 2-4. Purge for 45 minutes just before starting normal pre-propellant loading purges.

b. Where applicable, the oxidizer dome nitrogen purge (CO3a) may be substituted for helium purge of step a. (See figure 2-1.) Purge for 45 minutes just before starting normal pre-propellant loading purges outlined in figures 2-1 through 2-4.

NOTE

Steps c through f provide an alternate method of removing moisture if the thrust chamber temperature monitored at the main fuel injector temperature transducer (CFT2) is at or below 35° F.

c. Place four 250-watt heating lamps inside thrust chamber, 0-5 inches below thrust chamber throat. Heat lamps must be directed at thrust chamber injector.

d. Turn on heat lamps for 3 hours before loading propellants. During last 15 minutes of this period, purge oxidizer dome and GG oxidizer injector (engine pneumatic system) at pressures and temperatures outlined in figures 2-1 through 2-4.

e. After 3 hours of heat-lamp operation, turn off heat lamps and purges. Remove lamps from thrust chamber.

f. Within 15 minutes after turning off heat lamps, start normal pre-test purge procedures outlined in figures 2-1 through 2-4.

2.1.3.8 Fuel Feed System Purge Requirements. The engine fuel system must be conditioned before tanking propellants, by purging the system to all moisture and/or gases that could solidify or otherwise prove hazardous in contact with the liquid hydrogen. The only substance other than hydrogen that may be left in the system is helium. The procedure must make sure that the concentration of oxygen in the system is below the combustible limit (4 percent by volume).

a. Media: helium conforming to requirements of paragraph 2.1.2.2.

b. Pressure: 45 psia maximum.

c. Flowrate: A maximum helium gas flowrate of 70 scfm must not be exceeded through the fuel high-pressure duct.

CAUTION

Exceeding a flowrate of 70 scfm may cause dry-spinning of the fuel flowmeter. Dry-spinning in excess of 60 seconds can result in damage to the flowmeter.

d. Temperature: ambient.

e. Duration: Purge, as required, to reduce oxygen content in system to 4 percent or less by volume.

2.1.4 OXIDIZER FEED REQUIREMENTS.

a. Fluid specification: liquid oxygen (MIL-P-25508).

b. Fluid cleanness:

(1) Filtration: 72-micron nominal, 175-micron absolute, rated filters as determined by bubble-point testing.

(2) Maximum total hydrocarbon content: 75 ppm.

(3) Maximum acetylene content: 1.5 ppm.

c. Purity: not less than 99.2 percent.

d. Particulate content: not to be limited by total weight.

e. Nominal fluid flowrate: 27,600 lb/min at 230,000 pounds thrust or 27,066 lb/min at 225,000 pounds thrust.

f. Fluid pressure-temperature: within limits of figures 2-5 through 2-7.

g. Supply transient pressures: Maximum surge pressure at engine start and cutoff is 132 psia.

2.1.4.1 Oxidizer System Conditioning Requirements for Static Test. The engine oxidizer system oxidizer inlet duct, oxidizer turbopump, high-pressure oxidizer duct to main oxidizer valve, and GG oxidizer line to oxidizer bleed line connection will be conditioned.

a. Propellant in engine system before start: 2 hours minimum for one-second fuel lead, one hour minimum for 3-second fuel lead, and 5 minutes minimum for 8-second fuel lead.

b. Oxidizer circulation duration (total): 120 minutes minimum for one-second fuel lead and 5 minutes minimum for 3- and 8-second fuel leads.

c. Duration of circulation with subcooled liquid at engine inlet before engine start: 3 minutes minimum.

d. Circulation flowrate: Oxidizer circulation flowrate and duration must be sufficient to obtain 3° F subcooled or colder (figure 2-8), measured at instrumentation port POT3, in oxidizer high-pressure duct before engine start.

e. Engine inlet propellant condition at engine start: within requirements of figures 2-5, 2-6, and 2-7.

2.1.4.2 Oxidizer System Conditioning Requirements for Launch. The oxidizer system inlet duct, oxidizer turbopump, high-pressure oxidizer duct to main oxidizer valve, and GG oxidizer line to oxidizer bleed line connection will be conditioned.

a. Propellant in engine system before start: 2 hours minimum for SII stage, one hour minimum for SIVB-stage first start, and 3 minutes minimum for SIVB-stage second start.

b. Oxidizer circulation system duration and flowrate: Oxidizer circulation duration and flowrate must be sufficient to obtain temperature of 3° F subcooled or colder (figure 2-8), measured at instrumentation port POT3, in oxidizer high-pressure duct before engine start.

c. Oxidizer circulation with subcooled liquid at engine inlet before engine start: 3 minutes minimum.

d. Engine inlet propellant condition at engine start: within requirements of figures 2-5, 2-6, 2-6A, and 2-7.

2.1.5 FUEL FEED REQUIREMENTS.

a. Fluid specification: liquid hydrogen (MIL-P-27201).

b. Fluid cleanness: Liquid hydrogen must be supplied from a system equipped with 72-micron nominal, 175-micron absolute, rated filters as determined by bubble-point testing.

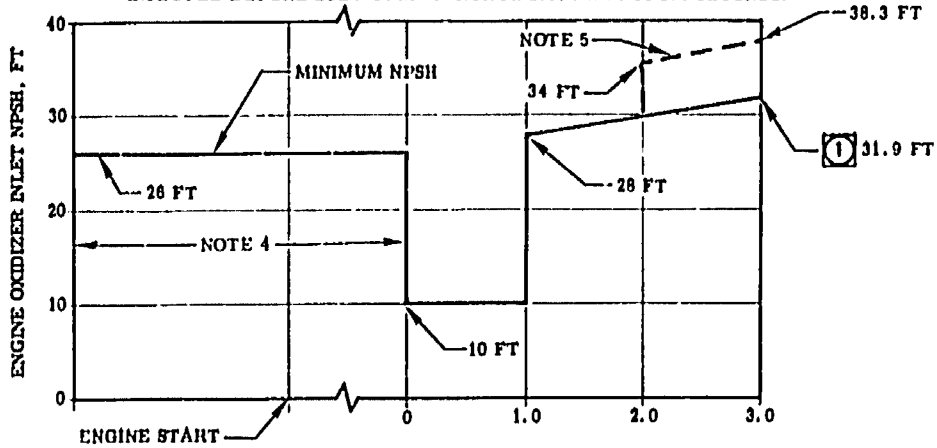
c. Nominal fluid flowrate: 5,046 lb/min at 230,000 pounds thrust or 4,950 lb/min at 225,000 pounds thrust.

d. Fluid pressure-temperature: within limits of figures 2-7, 2-9, and 2-10.

e. Supply transient pressure: Maximum surge pressure at engine start and cutoff is 132 psia.

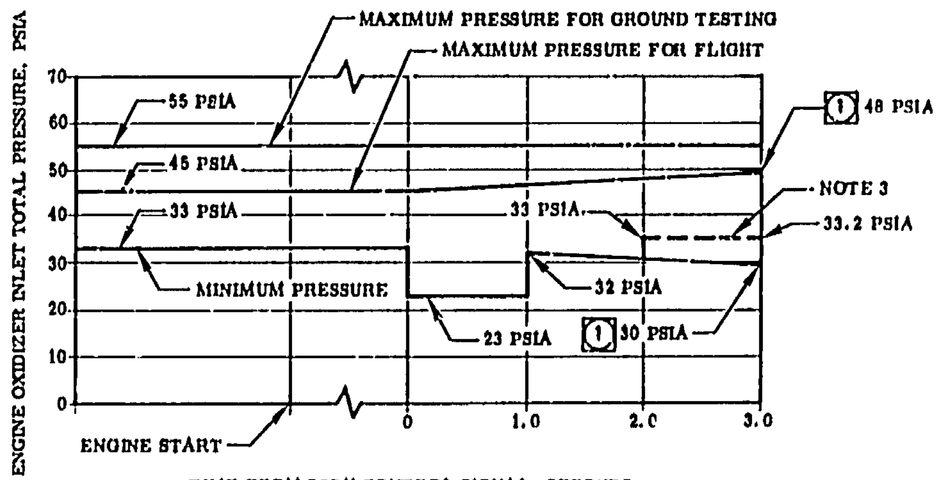
OXIDIZER NET POSITIVE SUCTION HEAD MINIMUM REQUIREMENTS

NOTES:
1. FLIGHT REQUIREMENTS ARE BASED ON ZERO CONDITIONS.
2. OSCILLATIONS MUST REMAIN ABOVE MINIMUM NPSH LINE.
3. ENGINE OXIDIZER INLET TEMPERATURE MUST NOT BE COLDER THAN -298° F.
4. FOR ENGINE RESTART, MINIMUM NPSH REQUIREMENT IS NOT APPLICABLE UNTIL STDV CONTROL SIGNAL.
5. DASHED LINE MINIMUM NPSH APPLIES WHEN 0.004 TO 0.006 LB/SEC HELIUM IS INJECTED AT THE ENGINE INLET. HELIUM MUST NOT BE INJECTED BEFORE STDV OPEN CONTROL SIGNAL PLUS 2.0 SECONDS.



OXIDIZER INLET PRESSURE REQUIREMENTS

NOTES:
1. FLIGHT REQUIREMENTS ARE BASED ON ZERO G CONDITIONS.
2. OSCILLATIONS MAY EXCEED THE UPPER LIMIT BUT MUST REMAIN ABOVE THE LOWER LIMIT.
3. DASHED LINE MINIMUM PRESSURE APPLIES WHEN 0.004 TO 0.006 LB/SEC HELIUM IS INJECTED AT THE ENGINE INLET. HELIUM MUST NOT BE INJECTED BEFORE STDV OPEN CONTROL SIGNAL PLUS 2.0 SECONDS.



1
- ENGINES NOT INCORPORATING MD366 OR MD371 CHANGE, NULL TO FULL OPEN PU.
- ENGINES INCORPORATING MD371 CHANGE, MRCV SET FOR EMR OF 4.8.
- ENGINES INCORPORATING MD360 CHANGE, MRCV SET FOR EMR OF 4.5 TO 5.0.

J2-1B-30A

Figure 2-5. Engine Start Requirements for Oxidizer Inlet

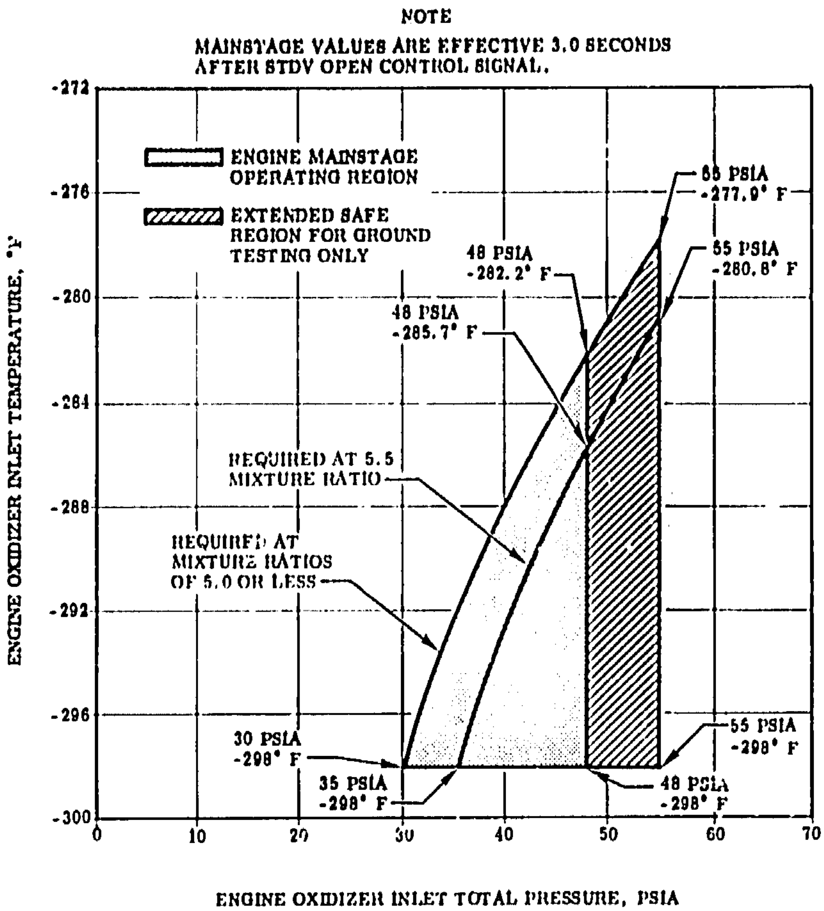


Figure 2-6. Engine Oxidizer Inlet Temperature Versus Inlet Total Pressure

2.1.5.1 Fuel System Conditioning Requirements for Static Test. The engine fuel system fuel inlet duct, fuel turbopump, high-pressure fuel duct to main fuel valve, and GG fuel line to fuel bleed line connection will be conditioned.

a. Propellant in engine system before engine start: 30 minutes minimum for 1- and 3-second fuel leads and 5 minutes minimum for 8-second fuel lead.

b. Duration of fuel circulation (total): 5 minutes minimum.

c. Duration of fuel circulation with subcooled liquid at engine inlet before engine start: 3 minutes minimum.

d. Circulation flowrate: 0.9 to 2.0 lb/sec.

e. Engine inlet propellant condition at engine start: within requirements of figures 2-7, 2-9, and 2-10.

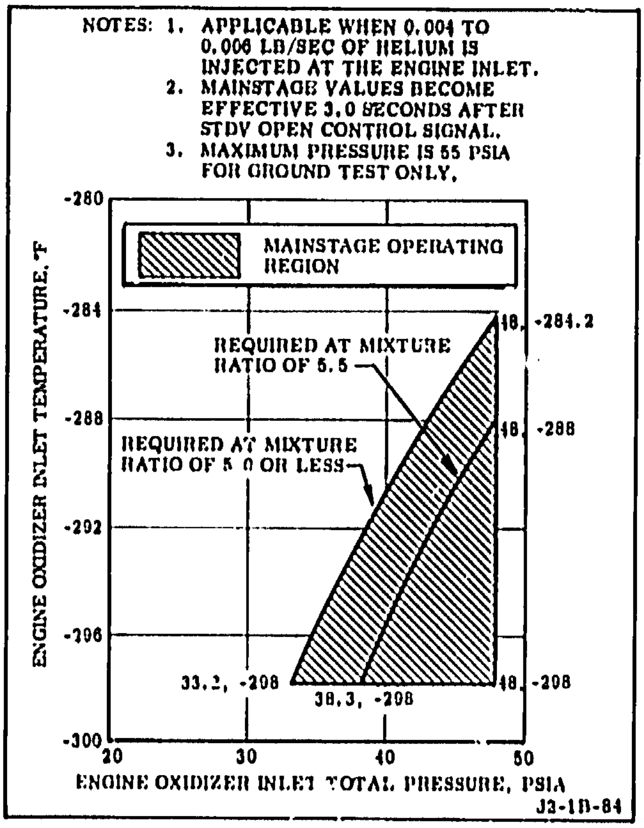


Figure 2-6A. Engine Oxidizer Inlet Temperature Versus Inlet Total Pressure (Engines With Helium Injection)

2.1.5.2 Fuel System Conditioning Requirements for Launch. The fuel system fuel inlet duct, fuel turbopump, high-pressure fuel duct to main fuel valve, and GG fuel line to fuel bleed line connection will be conditioned.

a. Propellant in engine system before start: 1/2 hour minimum for SII-stage and SIVB-stage first start, and 3 minutes minimum for SIVB-stage second start.

b. Duration of fuel circulation (total): 5 minutes minimum for SII-stage and SIVB-stage first start, and 3 minutes for SIVB-stage second start.

c. Duration of fuel circulation with subcooled liquid at engine inlet before engine start: 3 minutes minimum.

d. Circulation flowrate: 0.9 to 2.0 lb/sec.

e. Engine inlet propellant condition at engine start: within requirements of figures 2-7, 2-9, and 2-10.

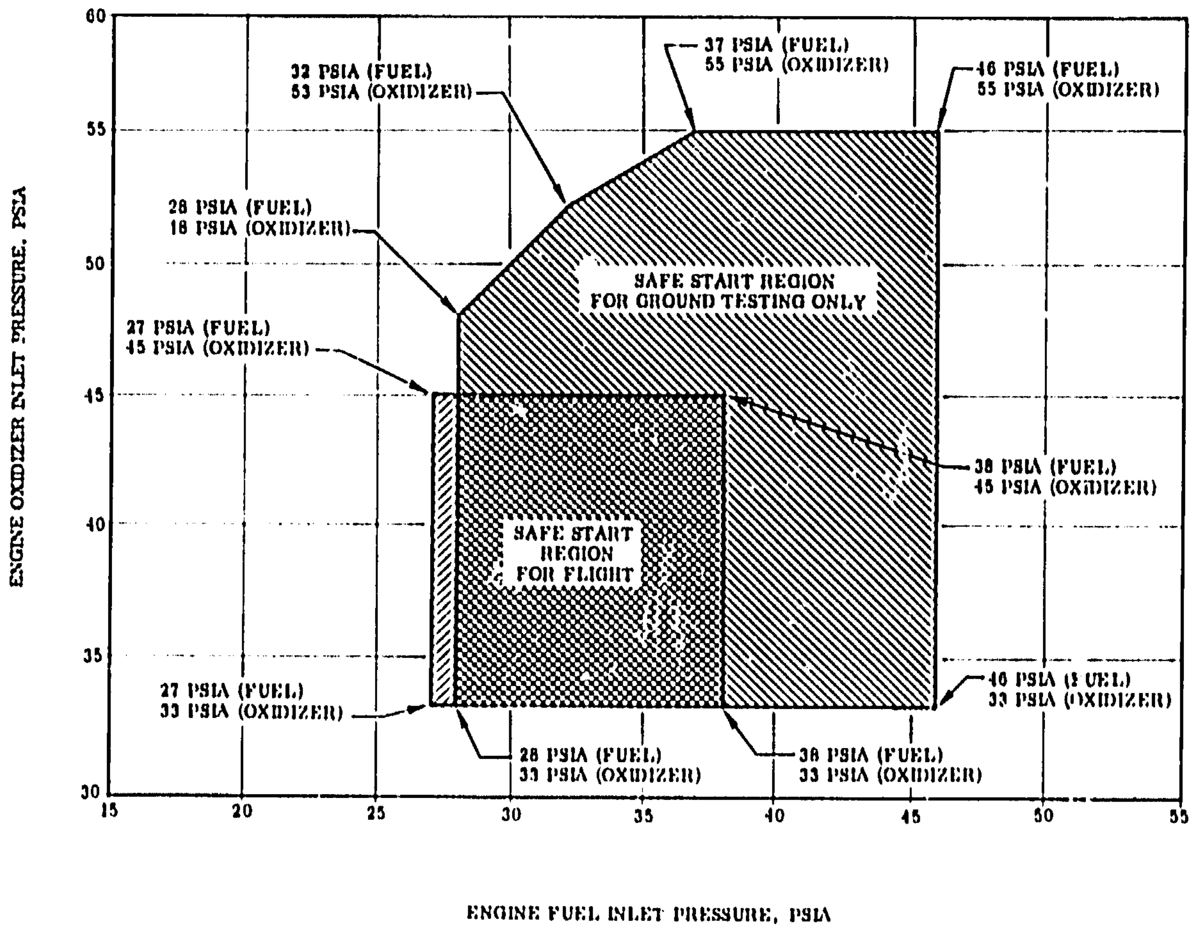


Figure 2-7. Engine Start Requirements for Engine Inlet Pressures

2.1.6 HELIUM TANK CONDITIONING REQUIREMENTS.

a. Media: helium conforming to requirements of paragraph 2.1.2.2.

b. Pressure: 2,800-3,450 psia measured in tank at engine start.

c. Temperature: Temperature must be within same temperature range as selected hydrogen start tank conditioning (paragraph 2.1.7).

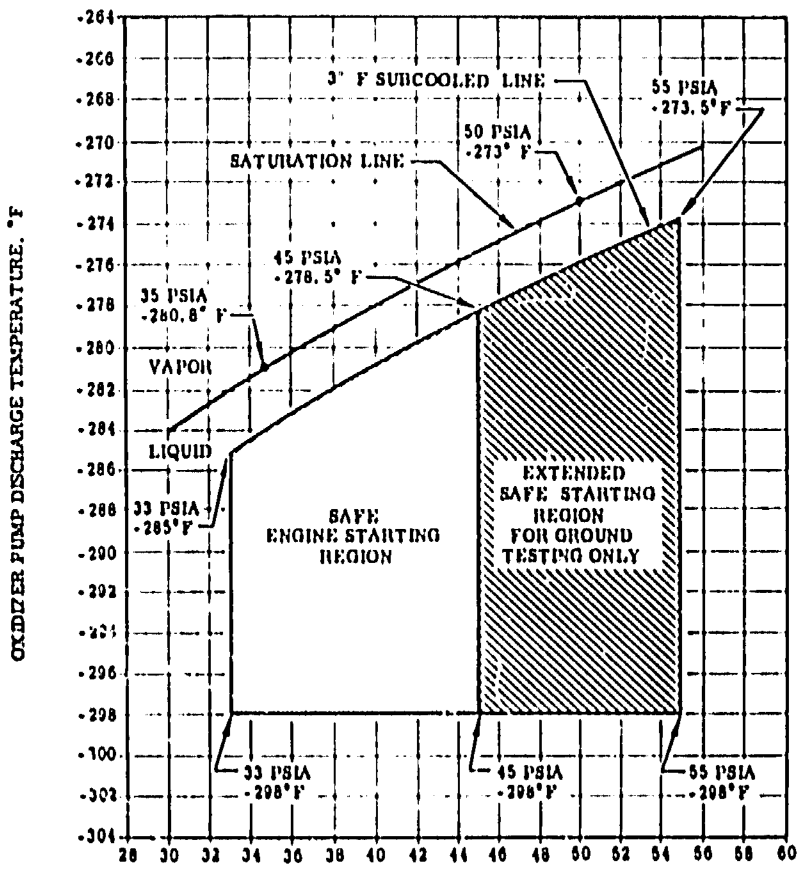
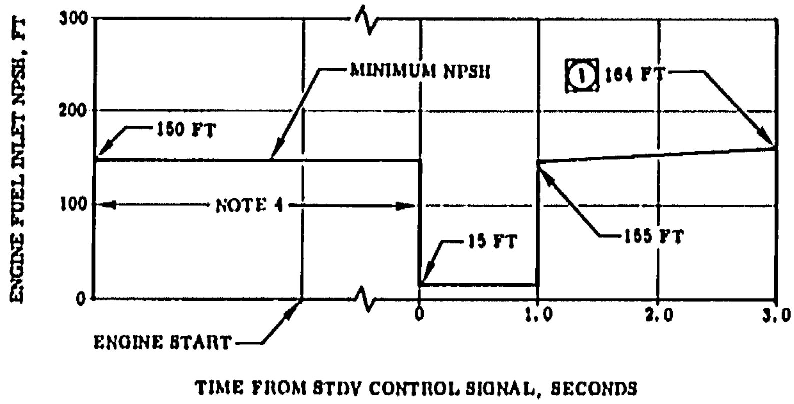


Figure 2-8. Oxidizer Turbopump Discharge Temperature Versus Pressure at Start

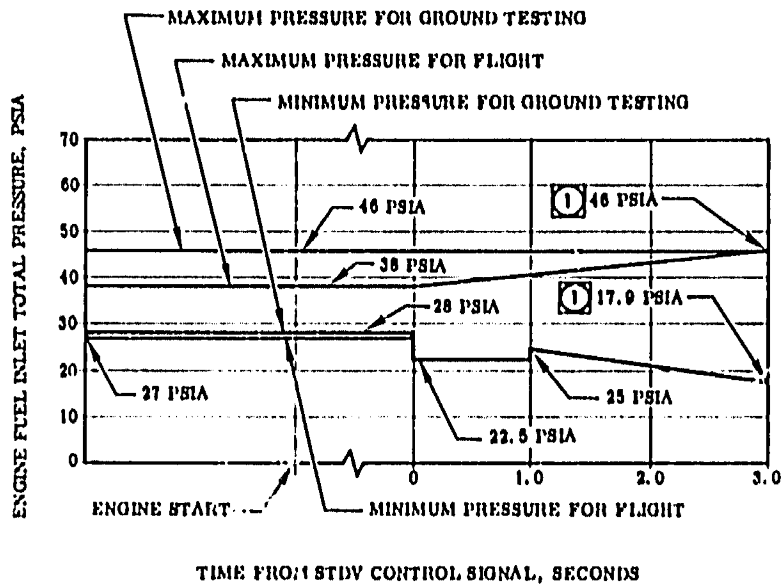
FUEL NET POSITIVE SUCTION HEAD MINIMUM REQUIREMENTS

NOTES: 1. FLIGHT REQUIREMENTS ARE BASED ON ZERO G CONDITIONS.
2. OSCILLATION MUST REMAIN ABOVE MINIMUM NPSH LINE.
3. ENGINE FUEL INLET TEMPERATURE MUST NOT BE COLDER THAN -424° F.
4. FOR ENGINE RESTART, MINIMUM NPSH REQUIREMENT IS NOT APPLICABLE UNTIL STDV CONTROL SIGNAL.



FUEL INLET PRESSURE REQUIREMENTS

NOTES: 1. FLIGHT REQUIREMENTS ARE BASED ON ZERO G CONDITIONS.
2. OSCILLATIONS MAY EXCEED THE UPPER LIMIT BUT MUST REMAIN ABOVE THE LOWER LIMIT.



1 ENGINES NOT INCORPORATING MD366 OR MD371 CHANGE, NULL TO FULL OPEN PU.
ENGINES INCORPORATING MD371 CHANGE, MRCV SET FOR EMR OF 4.8.
ENGINES INCORPORATING MD366 CHANGE, MRCV SET FOR EMR OF 4.5 TO 5.0.

J2-1B-32

Figure 2-9. Engine Start Requirements for Fuel Inlet

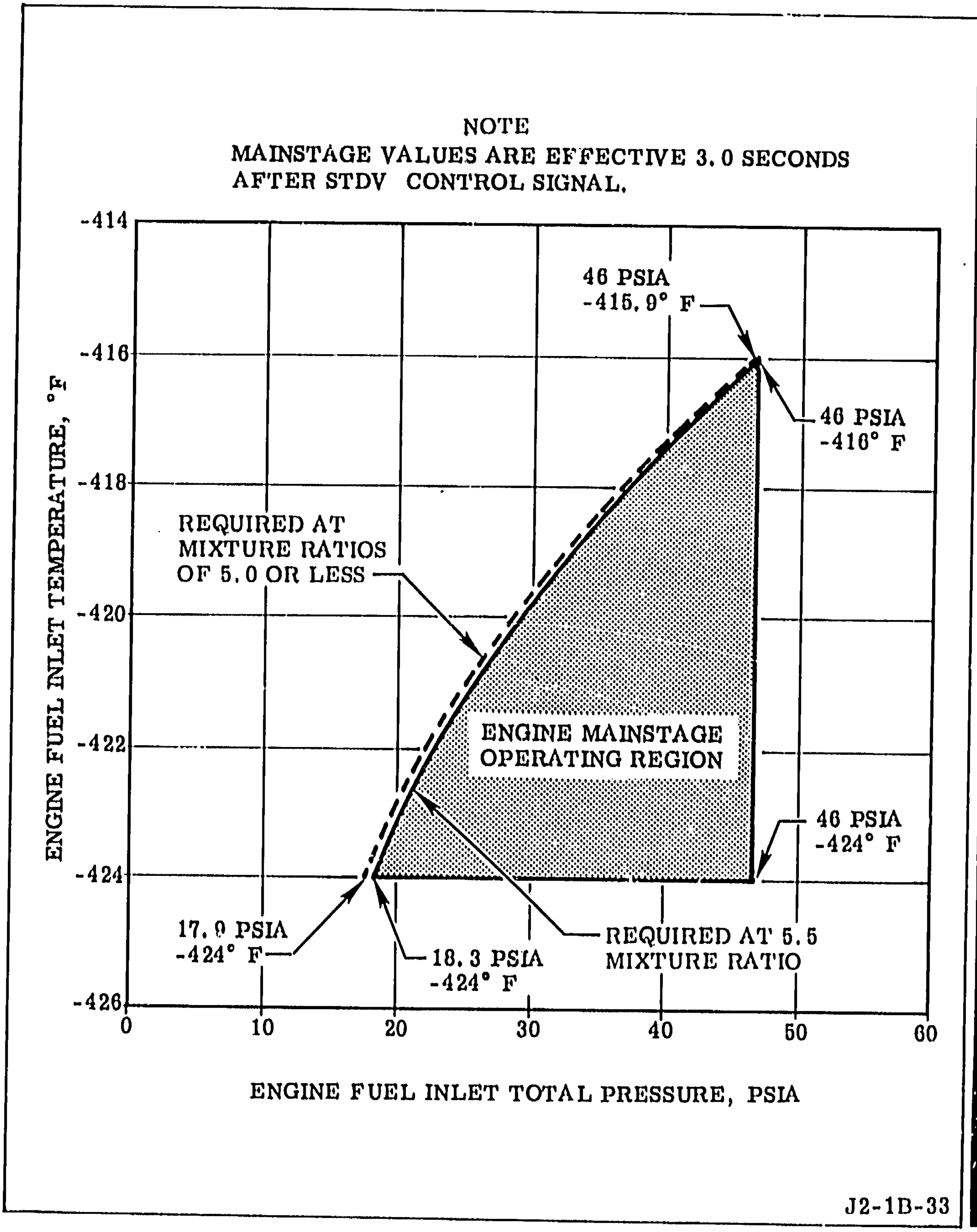


Figure 2-10. Engine Fuel Inlet Temperature Versus Inlet Total Pressure

2.1.7 START TANK CONDITIONING REQUIREMENTS.

a. Media: gaseous hydrogen conforming to requirements of paragraph 2.1.2.1.

b. Pressurization rate: The following start tank pressurization criteria must be met:

(1) When temperature and pressure are measured in start tank and inlet gas temperature at start tank initial-fill customer connect is not known or has not been verified, see figure 2-11 for required temperature and pressure and figure 2-12 (sheet 1 of 4) for maximum pressurization rate.

(2) When temperature and pressure are measured in start tank and inlet gas temperature at start tank initial-fill customer connect is known, see figure 2-11 for required temperature and pressure and figure 2-13 (sheet 3 of 4) for maximum pressurization rate.

(3) If the start tank facility supply has oscillatory pressure transients, the following relationship must be met:

$$f_1 x a \leq 20.0 + 0.022 P_B$$

where

f	=	frequency of oscillations in supply system, Hz
a	=	peak-to-peak amplitude of oscillations in supply system, psi
P_B	=	start tank pressure, psia
f_1	=	f (for $f \leq 1.0$ Hz)
f_1	=	1.0 (for $f > 1.0$ Hz)

c. Temperature and pressure: measured in the start tank and within limits of figure 2-11 at engine start.

2.1.7.1 Start Tank Vent-and-Relief Valve Constraints.

CAUTION

A reverse differential pressure in excess of 30 psi on the vent section of the valve can result in damage to the control section diaphragm.

a. Differential pressure: The pressure at the start tank vent-and-relief valve drain must not exceed pressure at the start tank vent valve control by more than 30 psi.

b. Actuation pressure: Unrestricted valve actuation is allowed at a maximum actuation pressure of 585 psia. A maximum of 100 actuation cycles is allowed at actuation pressures between 585 and 621 psia. If pressure in the range of 585-621 psia is applied to the valve control more than 100 times, the start tank vent-and-relief valve must be replaced.

2.1.7.2 Start Tank Helium Refill Constraints (Engines Incorporating MD301 Change). On engines incorporating MD301 change, the engine start tank can be replenished in flight from a stage helium tank. When the replenishing system is used, the following constraints apply:

a. The pressurization rate must be within the limits of figure 2-12 (sheet 2 of 4).

b. During functional checkout of the system, the stage tank pressure must be limited to 2,700-2,800 psia when the engine start tank pressure is ambient, and 1,400-1,450 psia when the engine start tank pressure is 1,200-1,300 psia and temperature is -100° to -300° F. These pressure limits will avoid a possible overpressurization of the systems.

c. During static test or launch preparation, the repressurization control valve must not be

actuated if the stage helium tank pressure is greater than the engine start tank pressure. If this constraint is violated, the engine start tank must be vented to remove the helium, and refilled with hydrogen.

d. Operational use of the replenishing system requires that refill of the engine start tank begin 30 seconds before engine start.

2.1.8 THRUST CHAMBER PRE-CHILL REQUIREMENTS.

a. Media: helium conforming to requirements of paragraph 2.1.2.2.

b. Pressure: 1,000 psia maximum.

c. Flowrate: 10-25 lb/min.

d. Duration (static test): Initiated a minimum of 7-1/2 to 30 minutes before engine start and continuous until engine start.

e. Duration (launch) for all stage engines: Initiated a minimum of 7-1/2 minutes before booster ignition. The maximum duration of purge varies for each stage application and is based on stage limitations, not engine requirements. The maximum stage limitation allows 30 minutes of uninterrupted pre-chill. Restart engines have no thrust chamber pre-chill requirements.

f. Temperature: -420° to -300° F measured at customer connect panel. The required temperature of the thrust chamber throat at engine start is -300° to 150° F for the SII-stage and SIVB-stage single start mission, and -300° to -80° F for the SIVB-stage restart mission.

2.1.9 HEAT EXCHANGER OUTPUT CONDITIONS.

2.1.9.1 Heat Exchanger Helium Output Conditions (SIVB Stage). Heat exchanger outlet temperature, pressure, and flowrate requirements must be within the limits specified in figure 2-13. The curves of figure 2-13 show the operating condition for an engine with maximum and minimum settings of the PU valve or MRCV.

2.1.9.2 Heat Exchanger Oxidizer Output Conditions (SII Stage). Heat exchanger outlet temperature, pressure, and flowrate requirements must be within the limits specified in figures 2-14 and 2-14A. The curves of figures 2-14 and 2-14A show the operating condition for an engine with maximum and minimum settings of the PU valve or MRCV.

2.1.10 FUEL TANK PRESSURIZATION CONDITIONS. Fuel tank pressurization, temperature, pressure, and flowrate requirements must be within limits specified in figures 2-15, 2-15A, and 2-15B. The curves of figures 2-15, 2-15A, and 2-15B show the operating conditions for an engine with maximum and minimum settings of the PU valve or MRCV.

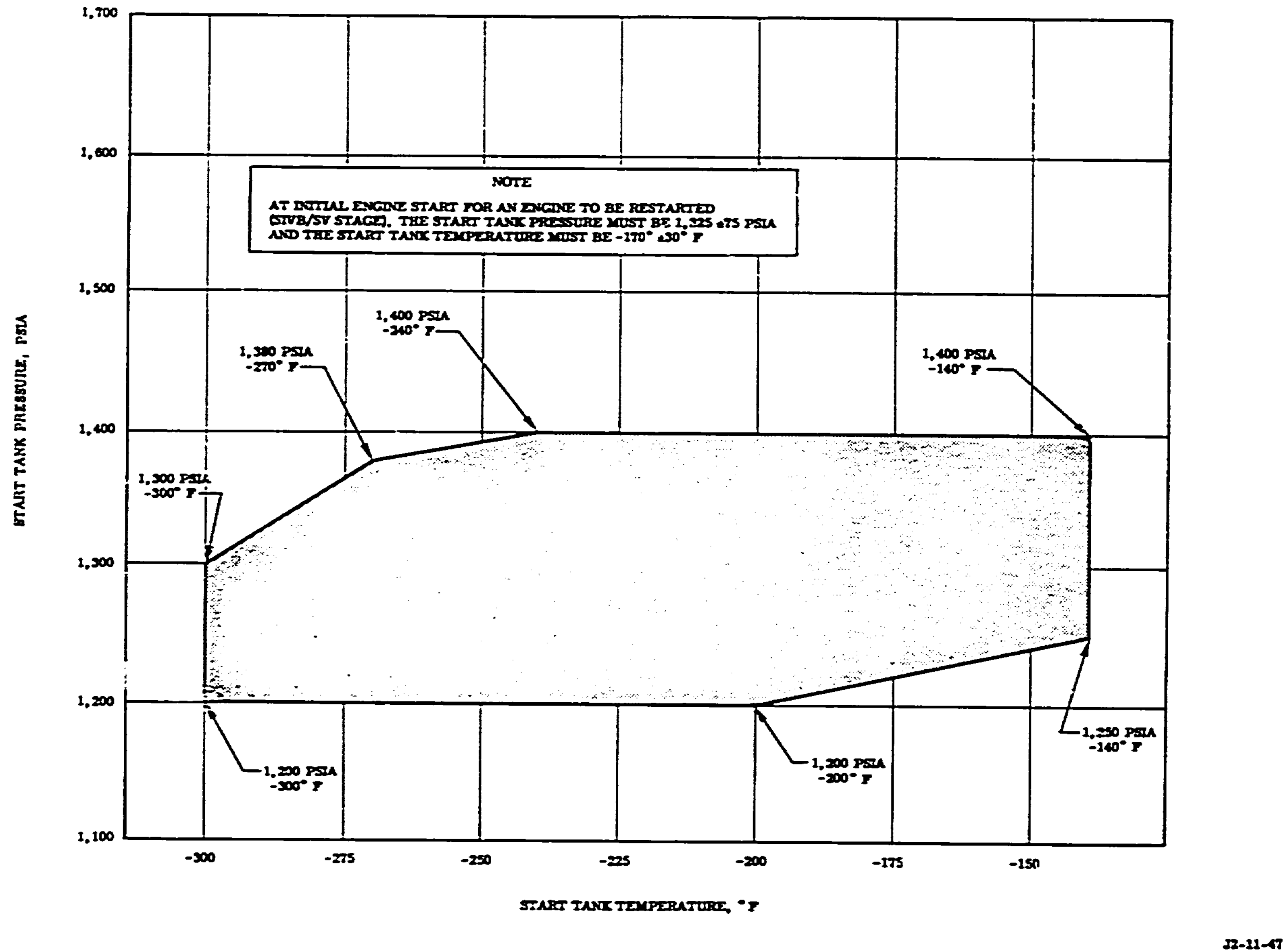


Figure 2-11. Start Tank Conditioning Requirements

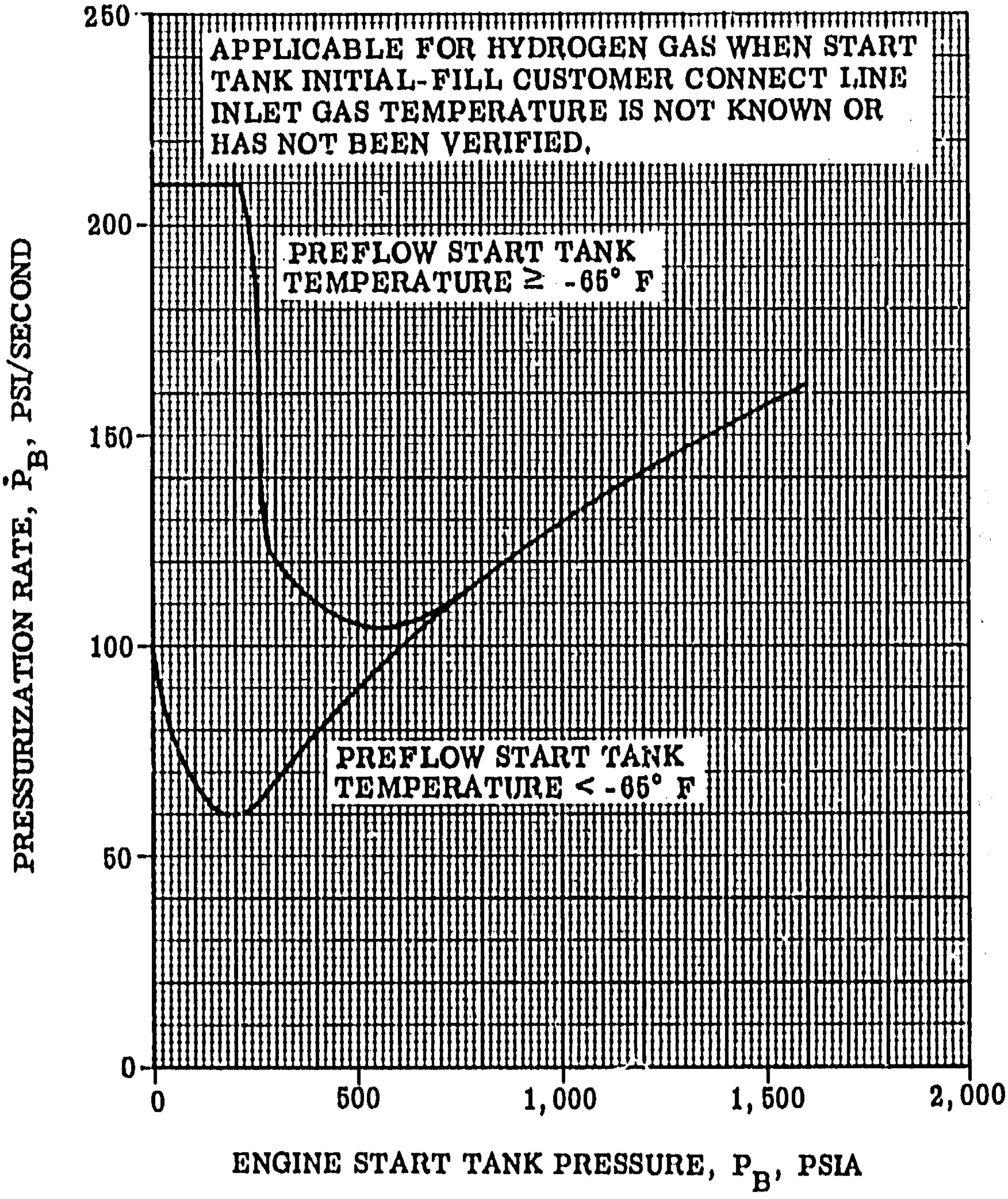


Figure 2-12. Start Tank Maximum Pressurization Rate (Sheet 1 of 4)

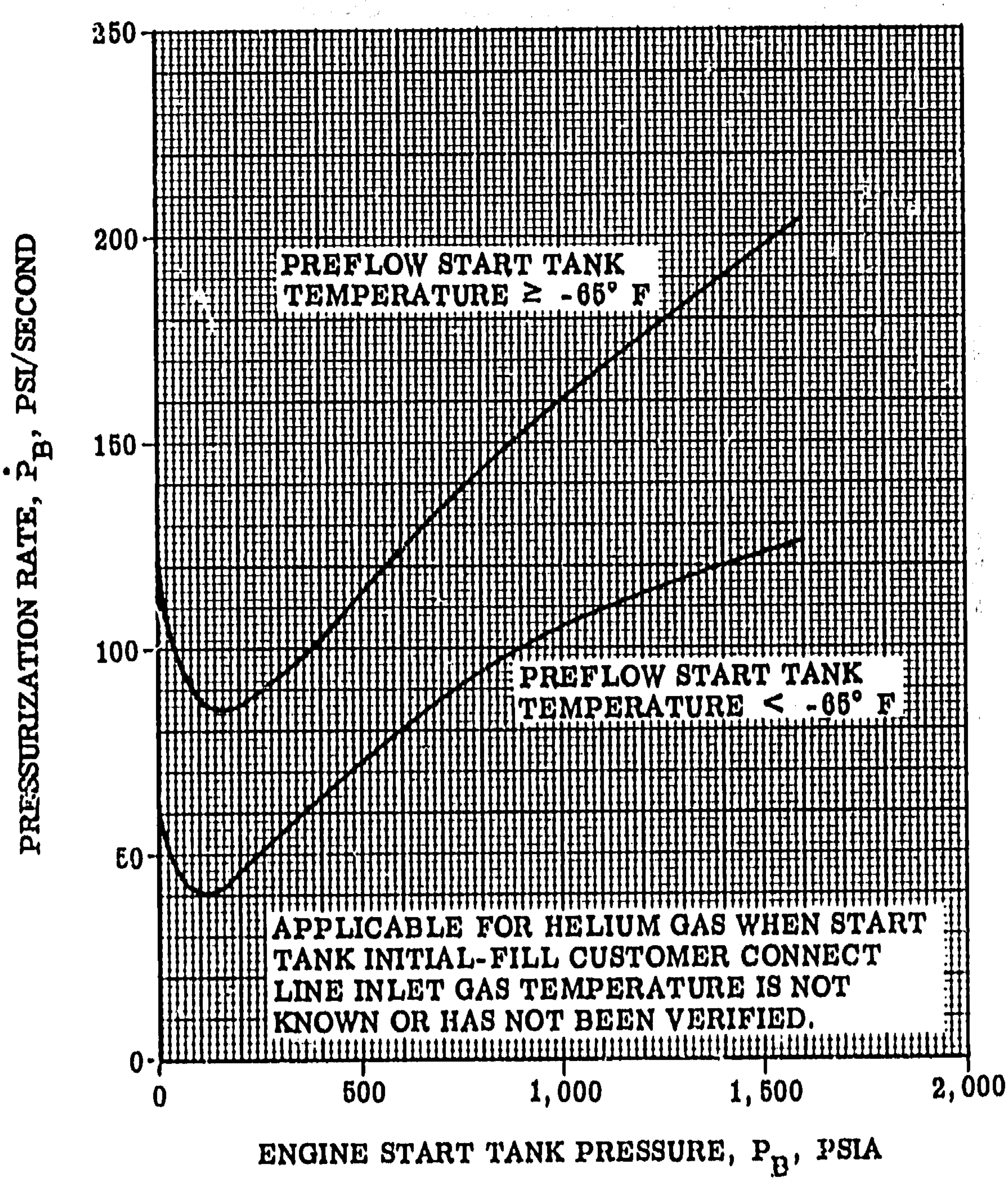


Figure 2-12. Start Tank Maximum Pressurization Rate (Sheet 2 of 4)

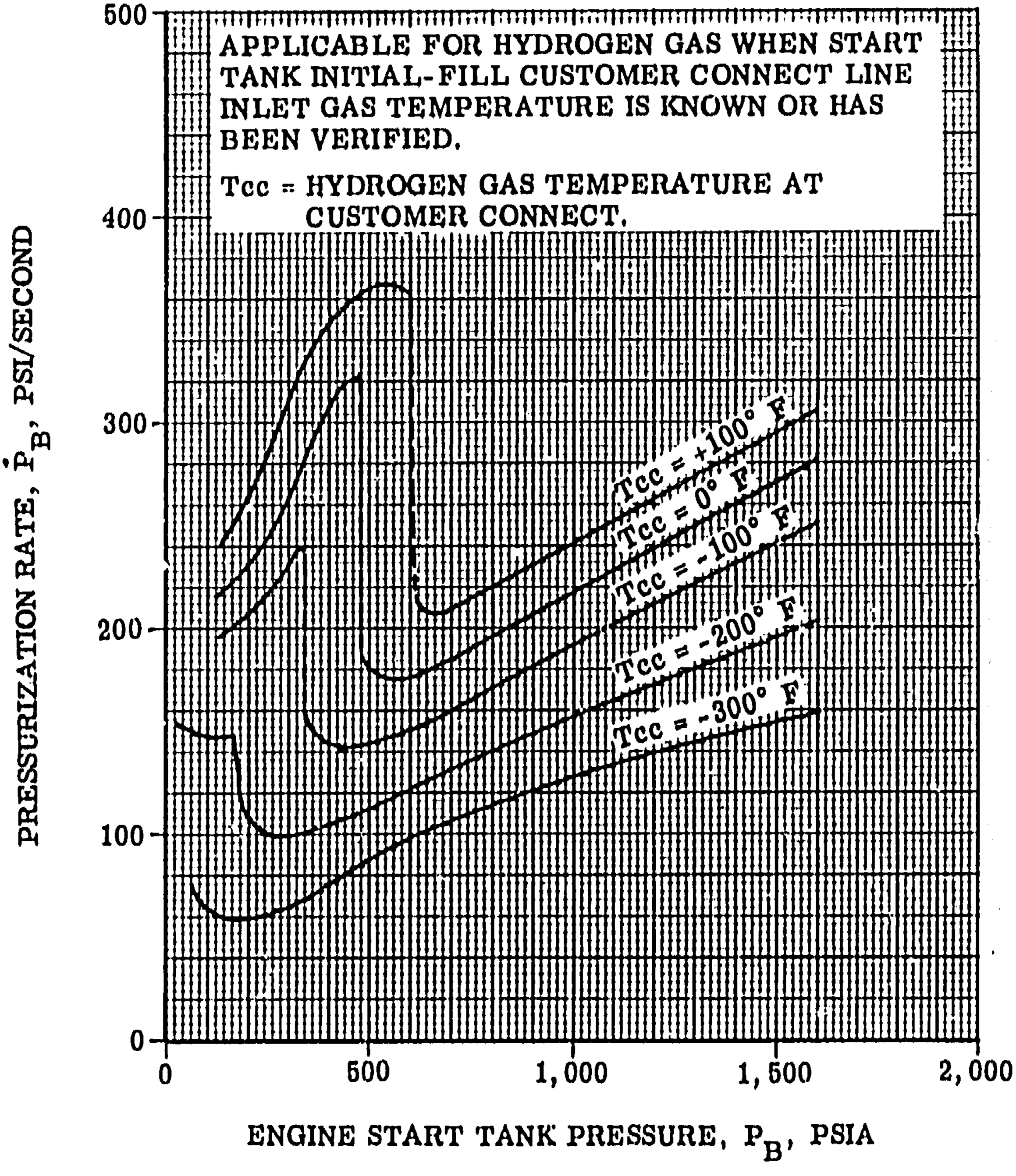


Figure 2-12. Start Tank Maximum Pressurization Rate (Sheet 3 of 4)

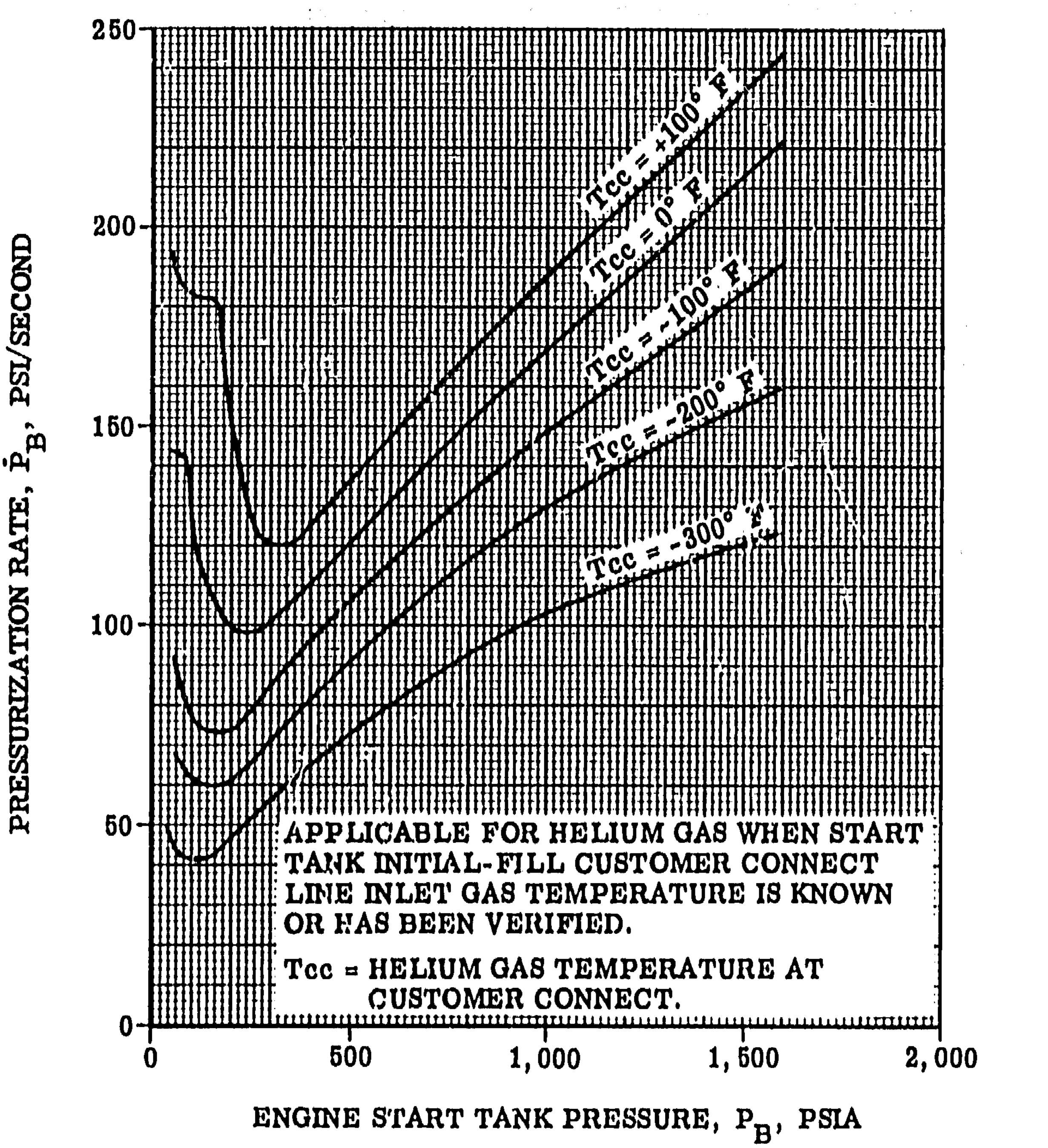


Figure 2-12. Start Tank Maximum Pressurization Rate (Sheet 4 of 4)

HEAT EXCHANGER OUTLET TEMPERATURE VERSUS HELIUM FLOWRATE USING TWO COILS (APPLICABLE FOR TIME PERIOD FROM 10-90 SECONDS AFTER STDV OPEN SIGNAL ON ENGINES NOT INCORPORATING MD366 OR MD371 CHANGE)

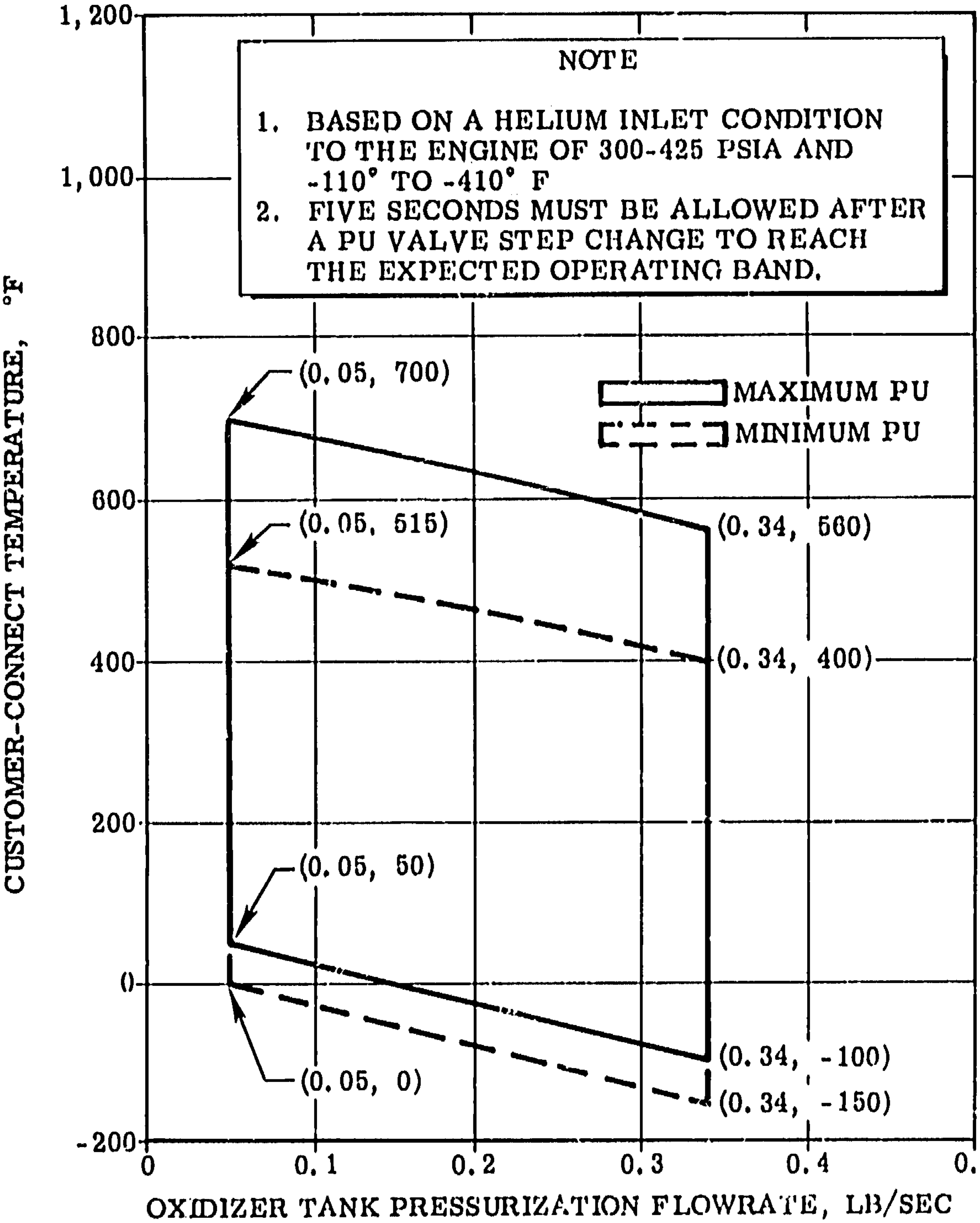
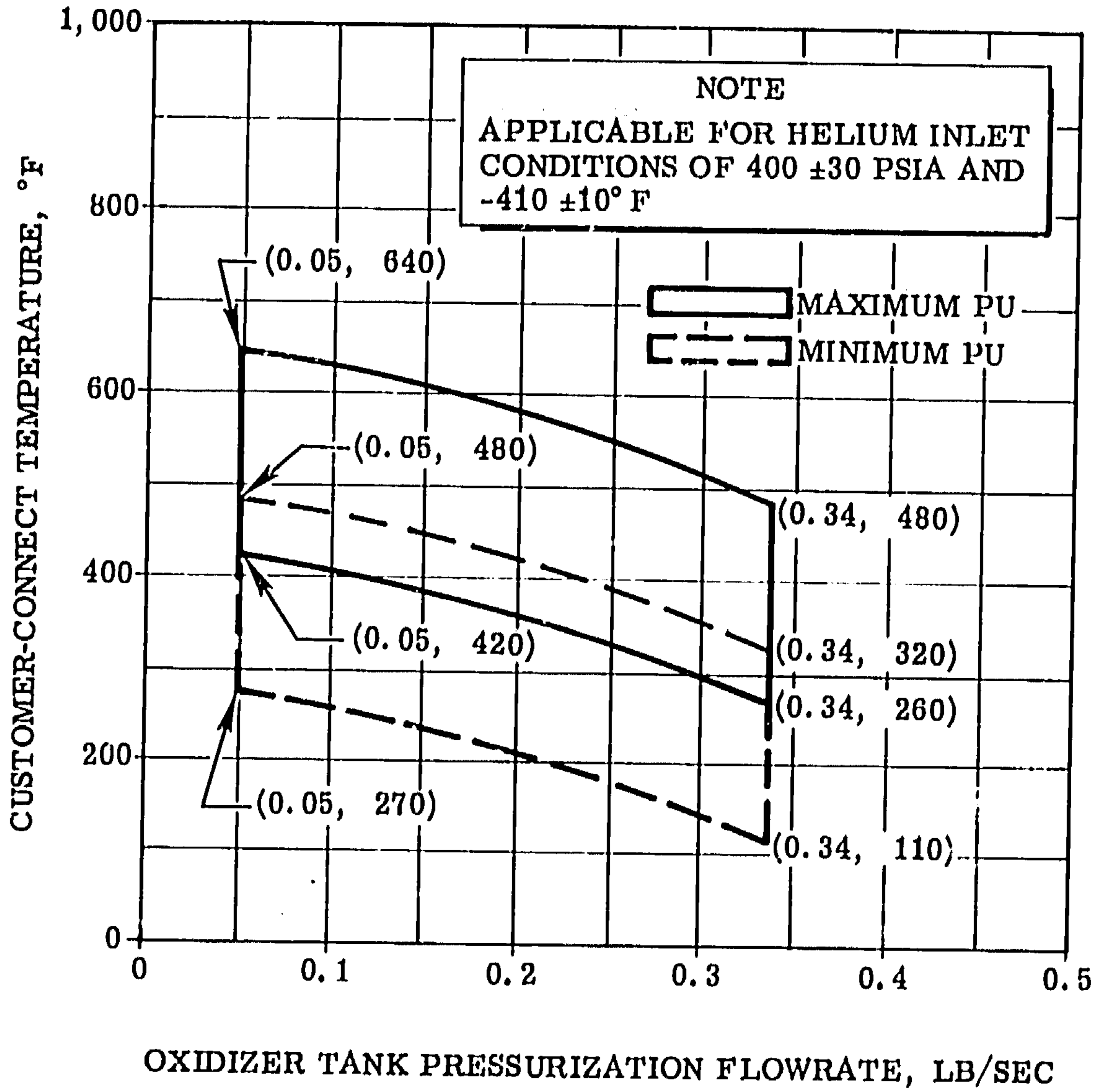


Figure 2-13. Heat Exchanger Helium Output Conditions (SIVB Stage) (Sheet 1 of 6)

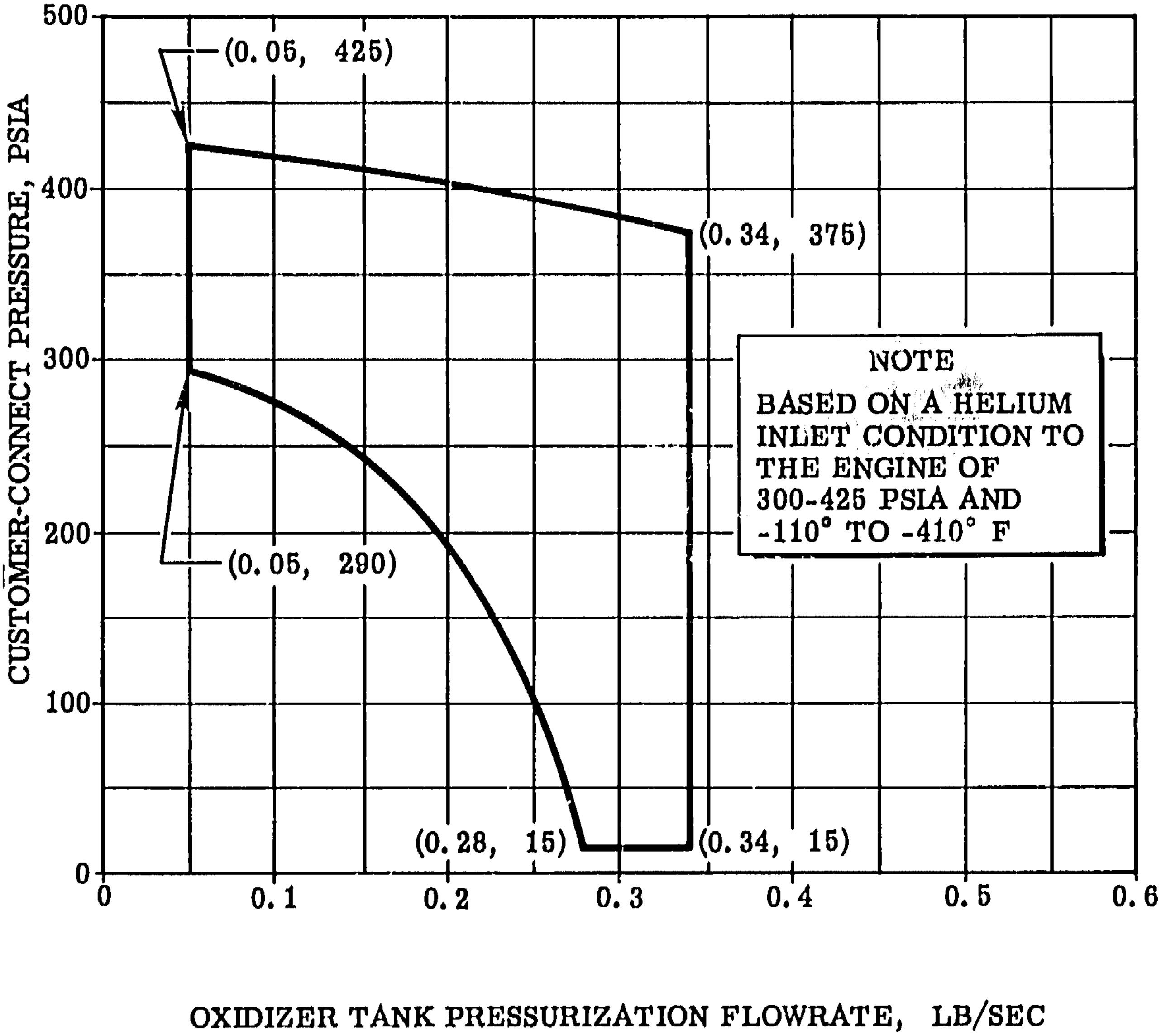
HEAT EXCHANGER OUTLET TEMPERATURE VERSUS HELIUM FLOWRATE USING TWO COILS (APPLICABLE FOR TIME PERIOD STARTING 60 SECONDS AFTER STDV OPEN SIGNAL ON ENGINES NOT INCORPORATING MD366 OR MD371 CHANGE)



J2-1B-42

Figure 2-13. Heat Exchanger Helium Output Conditions (SIVB Stage) (Sheet 2 of 6)

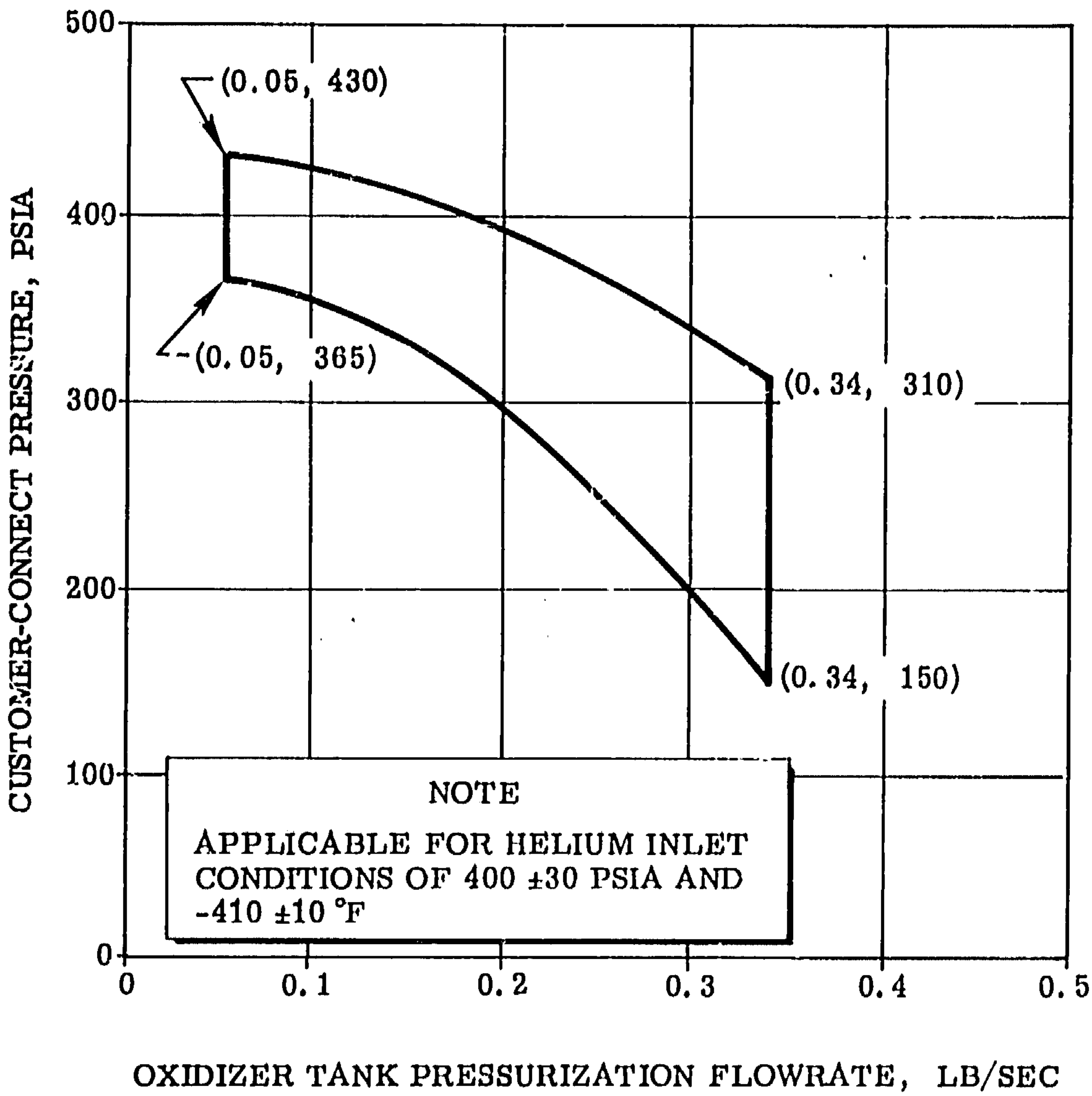
HEAT EXCHANGER OUTLET PRESSURE VERSUS HELIUM FLOW-RATE USING TWO COILS (APPLICABLE FOR TIME PERIOD FROM 10-90 SECONDS AFTER STDV OPEN SIGNAL)



J2-11-21

Figure 2-13. Heat Exchanger Helium Output Conditions (SIVB Stage) (Sheet 3 of 6)

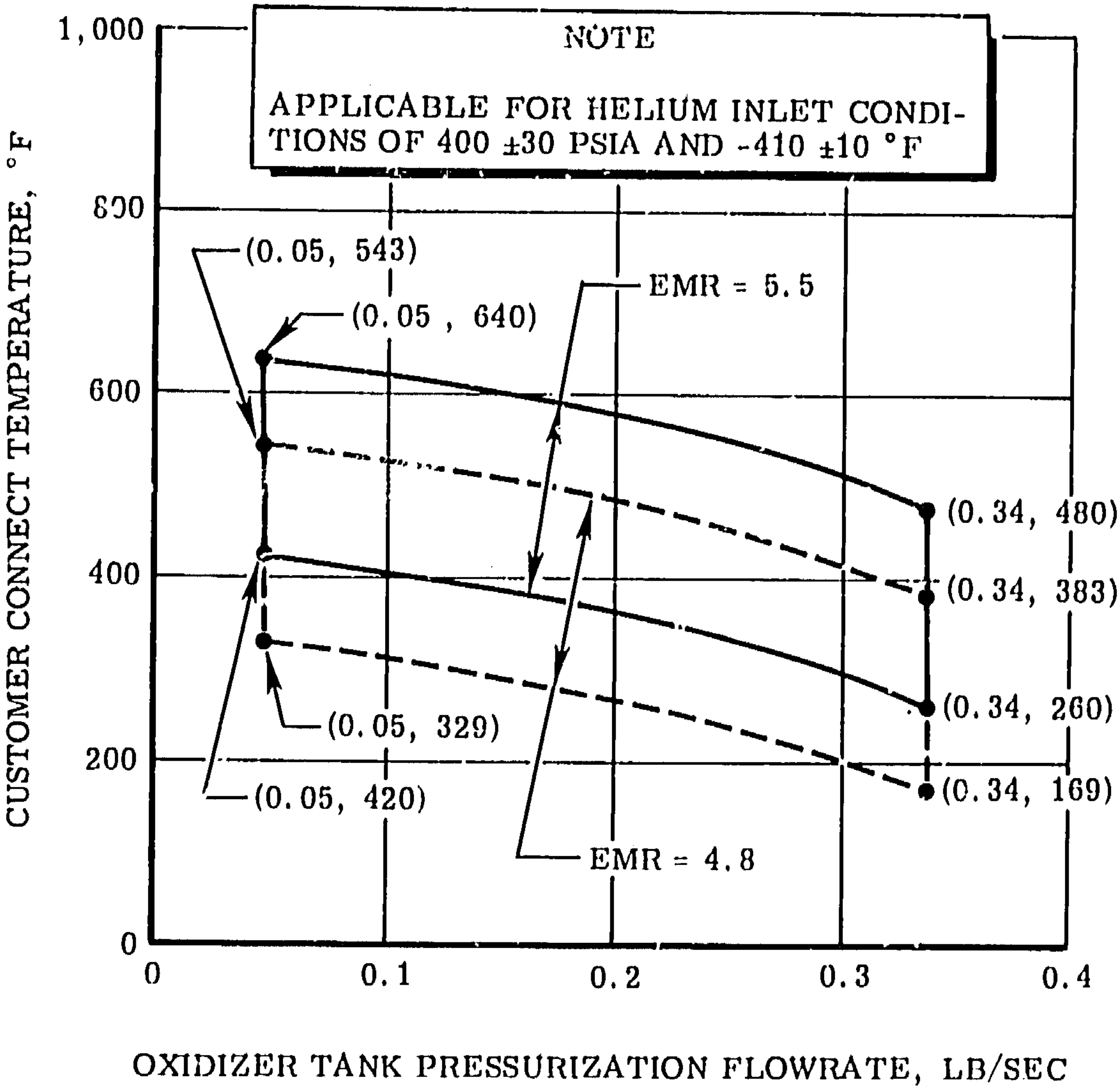
HEAT EXCHANGER OUTLET PRESSURE VERSUS HELIUM FLOWRATE USING TWO COILS (APPLICABLE FOR TIME PERIOD STARTING 60 SECONDS AFTER STDV OPEN SIGNAL)



J2-11-22A

Figure 2-13. Heat Exchanger Helium Output Conditions (SIVB Stage) (Sheet 4 of 6)

HEAT EXCHANGER OUTLET TEMPERATURE VERSUS HELIUM FLOWRATE USING TWO COILS (APPLICABLE FOR TIME PERIOD FROM 90 SECONDS AFTER STDV OPEN SIGNAL ON ENGINE INCORPORATING MD371 CHANGE)



J2-1B-43

Figure 2-13. Heat Exchanger Helium Output Conditions (SIVB Stage) (Sheet 5 of 6)

HEAT EXCHANGER OUTLET TEMPERATURE VERSUS HELIUM FLOWRATE USING TWO COILS (APPLICABLE FOR TIME PERIOD STARTING 90 SECONDS AFTER STDV OPEN SIGNAL ON ENGINES INCORPORATING MD366 CHANGE)

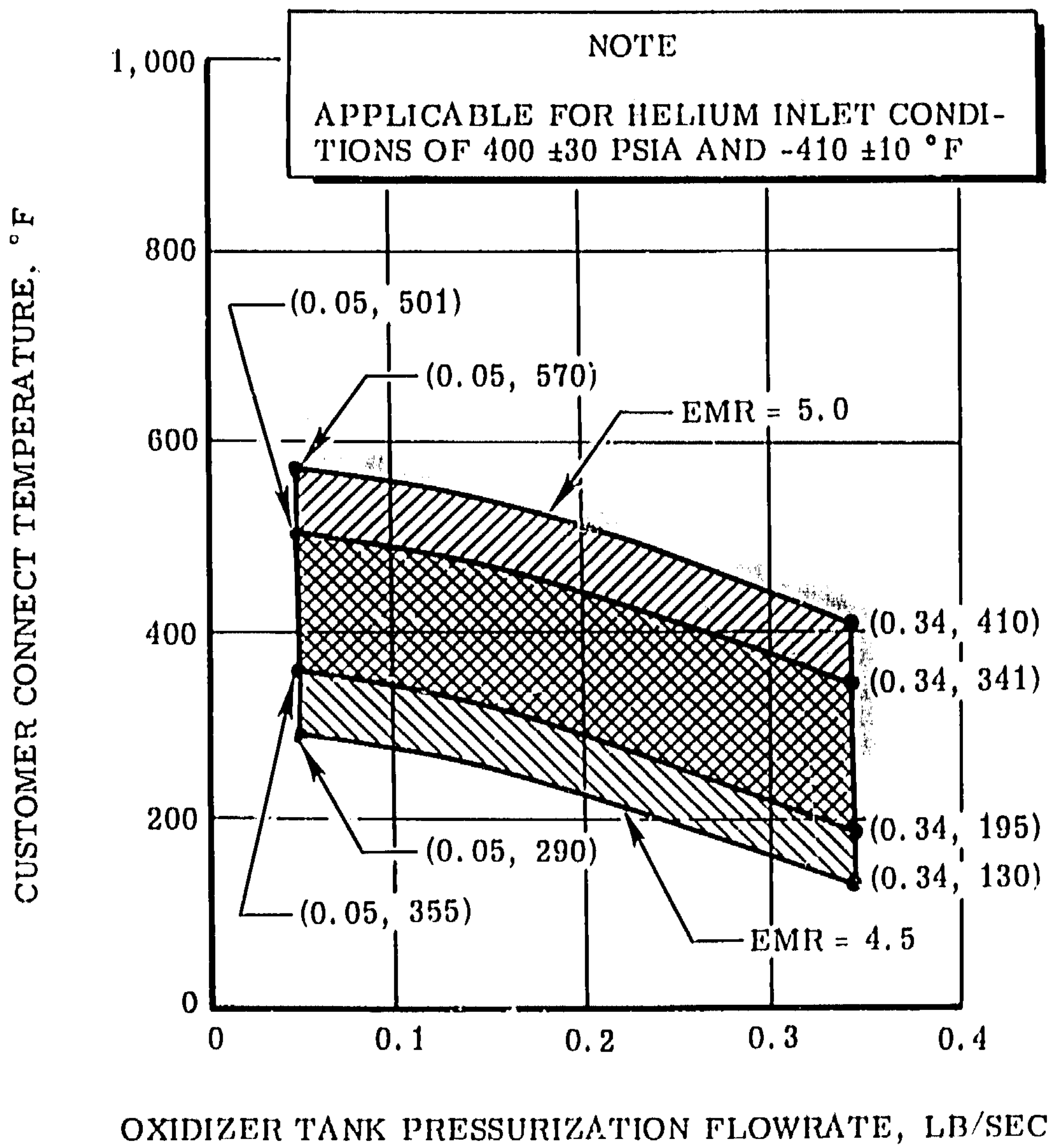


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Figure 2-13. Heat Exchanger Helium Output Conditions (SIVB Stage) (Sheet 6 of 6)

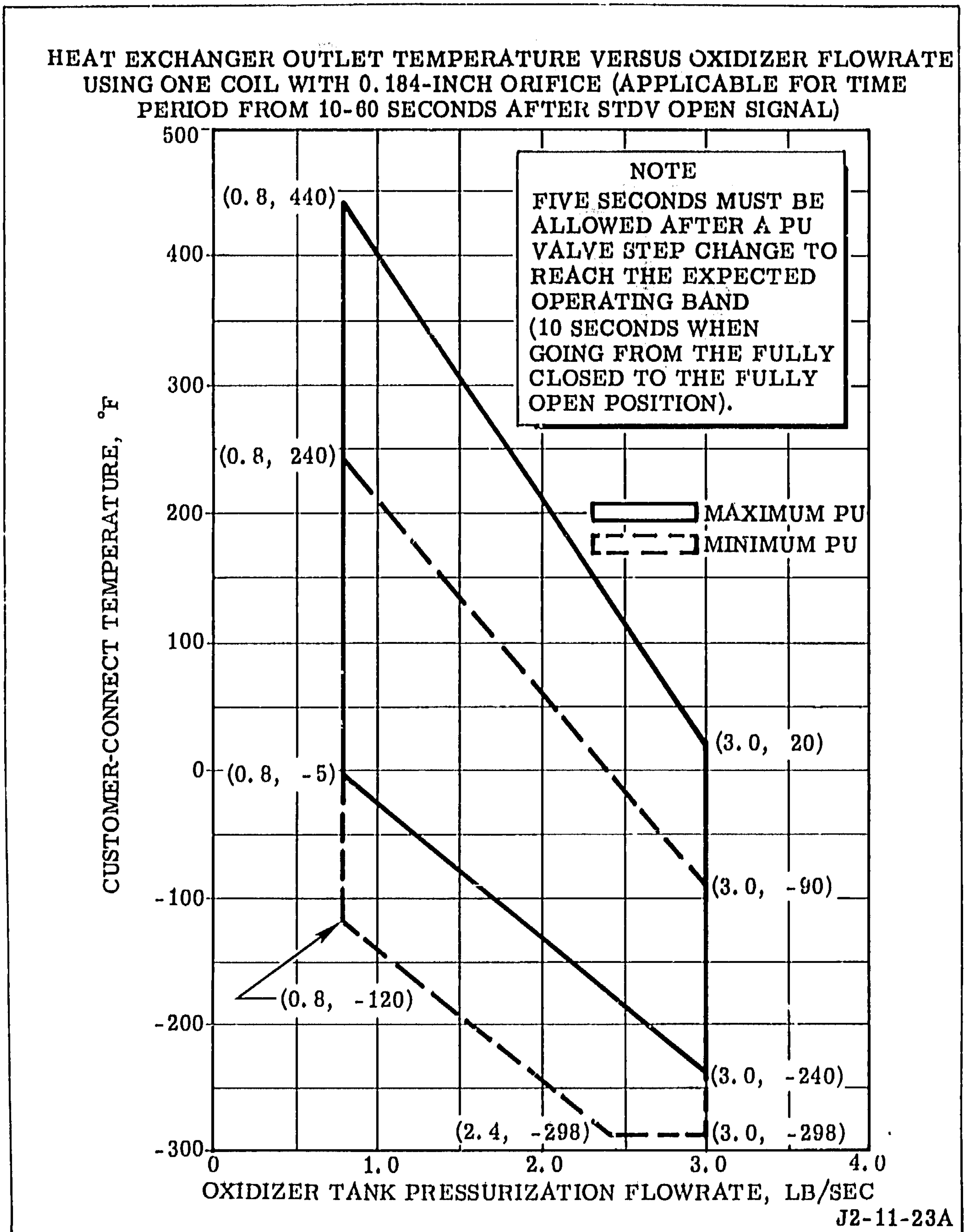


Figure 2-14. Heat Exchanger Oxidizer Output Conditions (SII Stage Engines Not Incorporating MD371 Change) (Sheet 1 of 6)

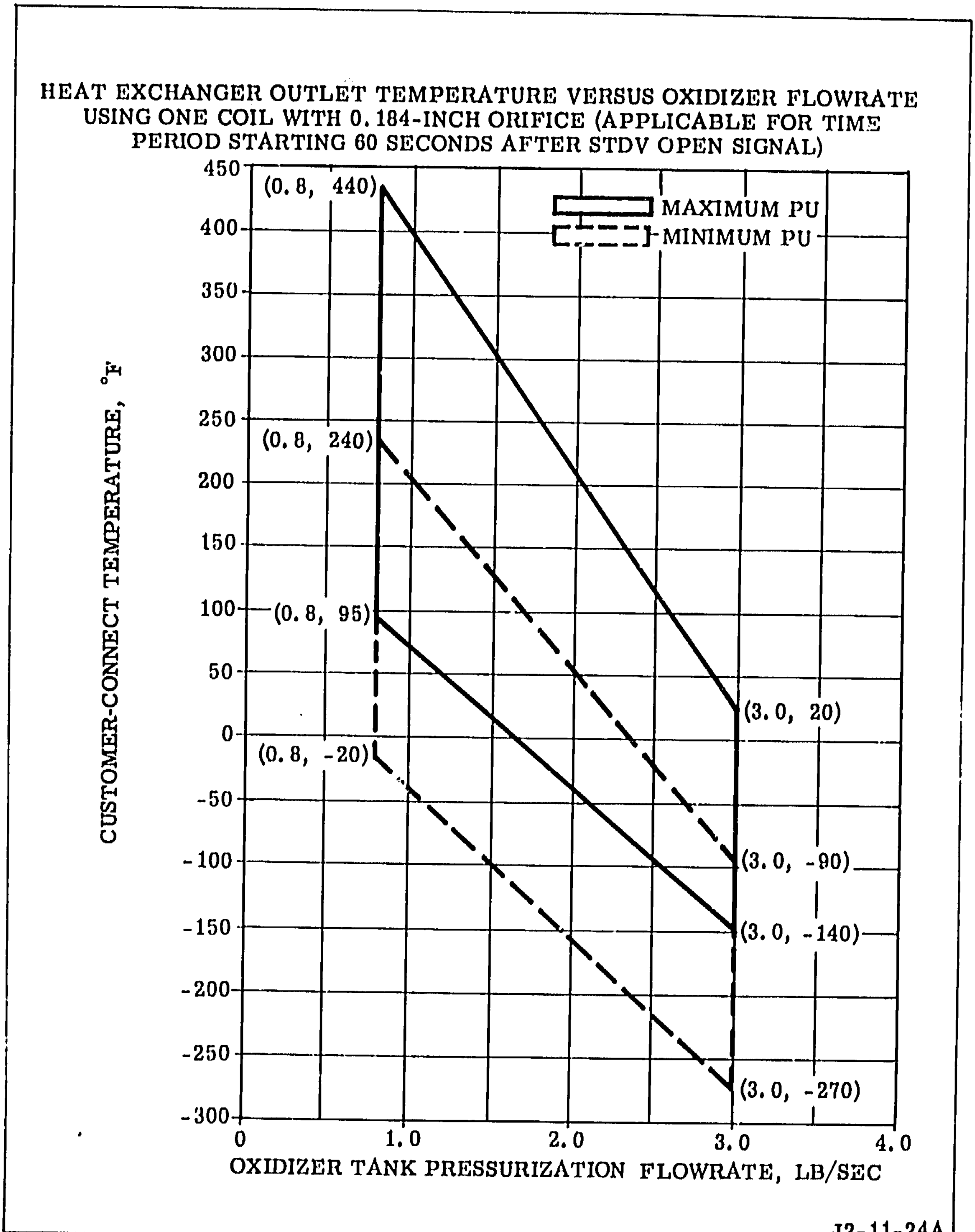


Figure 2-14. Heat Exchanger Oxidizer Output Conditions (SII Stage Engines Not Incorporating MD371 Change) (Sheet 2 of 6)

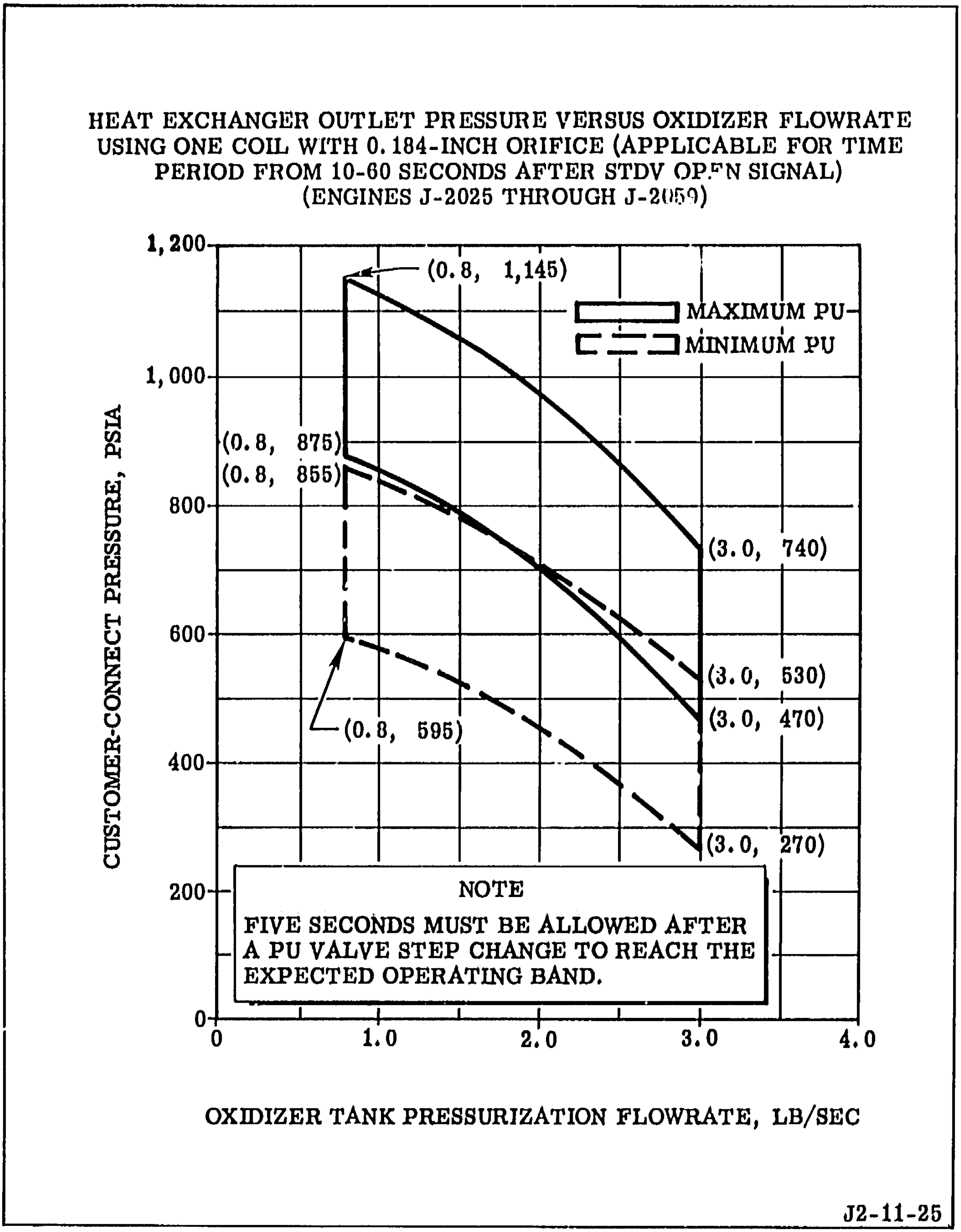
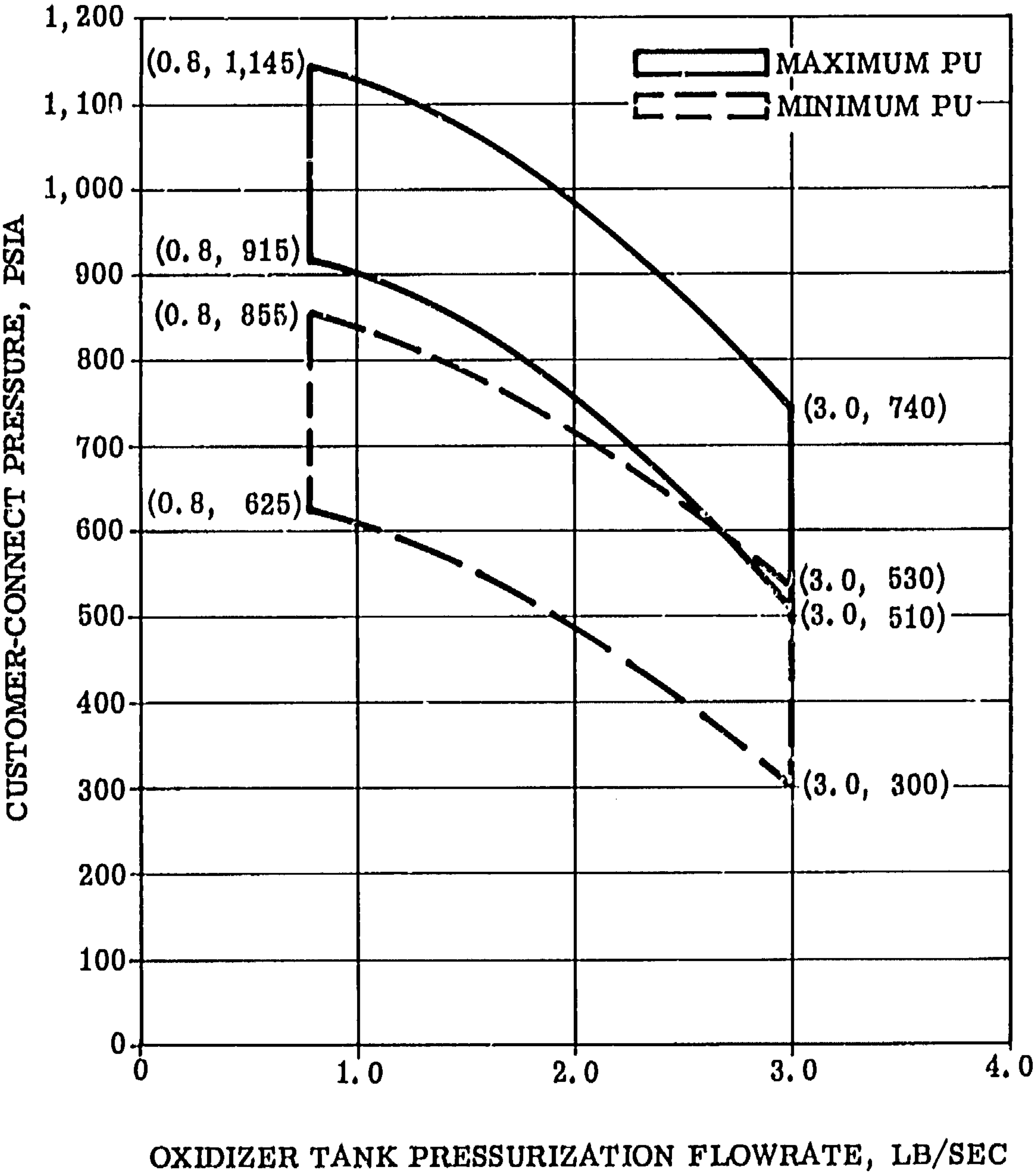


Figure 2-14. Heat Exchanger Oxidizer Output Conditions (SII Stage Engines Not Incorporating MD371 Change) (Sheet 3 of 6)

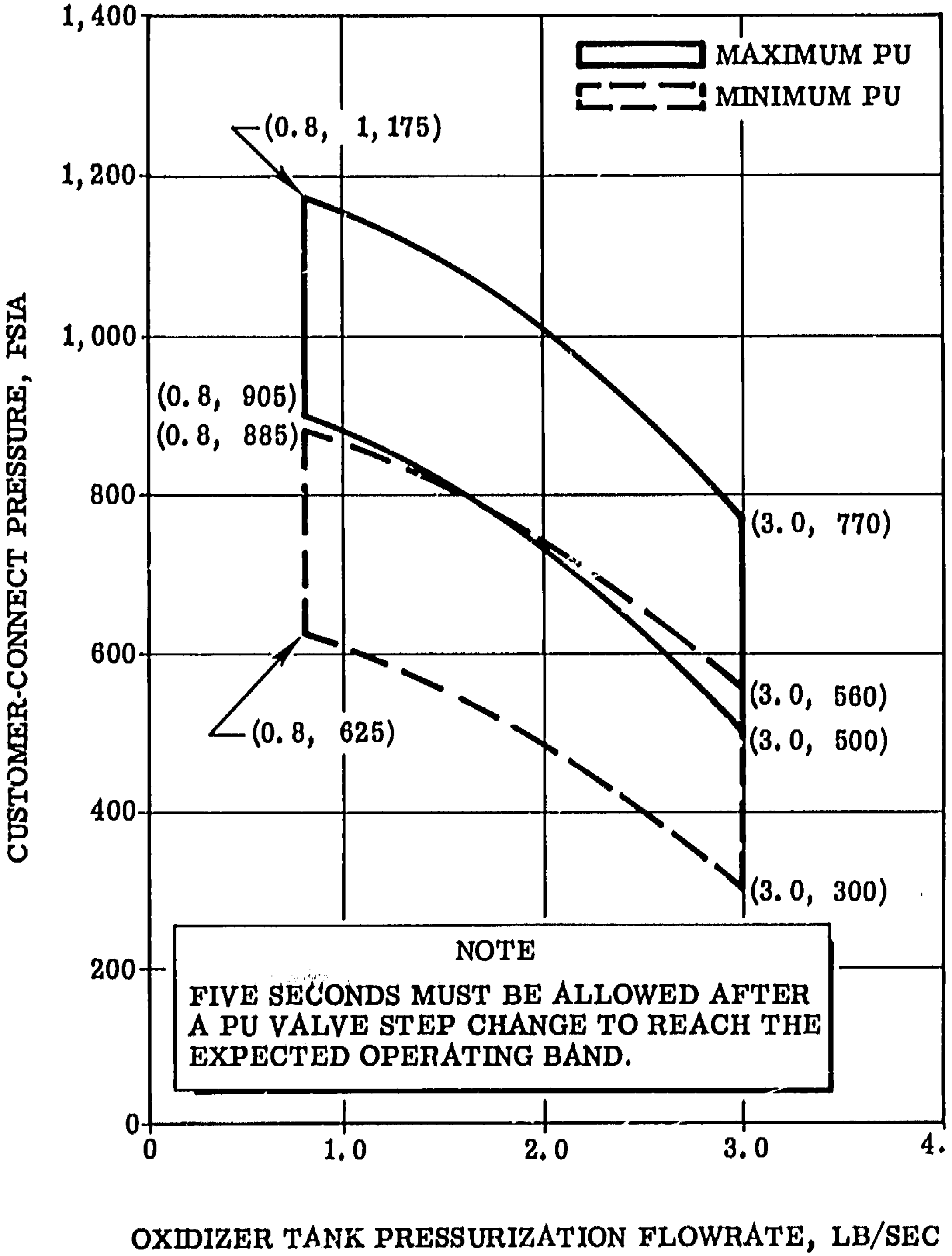
HEAT EXCHANGER OUTLET PRESSURE VERSUS OXIDIZER FLOWRATE USING ONE COIL WITH 0.184-INCH ORIFICE (APPLICABLE FOR TIME PERIOD STARTING 60 SECONDS AFTER STDV OPEN SIGNAL) (ENGINES J-[illegible] THROUGH J-2059)



J2-11-26

Figure 2-14. Heat Exchanger Oxidizer Output Conditions (SII Stage Engines Not Incorporating MD371 Change) (Sheet 4 of 6)

HEAT EXCHANGER OUTLET PRESSURE VERSUS OXIDIZER FLOWRATE USING ONE COIL WITH 0.184-INCH ORIFICE (APPLICABLE FOR TIME PERIOD FROM 10-60 SECONDS AFTER STDV OPEN SIGNAL) (ENGINES J-2060 AND SUBSEQUENT)



NOTE

FIVE SECONDS MUST BE ALLOWED AFTER A PU VALVE STEP CHANGE TO REACH THE EXPECTED OPERATING BAND.

J2-11-27

Figure 2-14. Heat Exchanger Oxidizer Output Conditions (SII Stage Engines Not Incorporating MD371 Change) (Sheet 5 of 6)

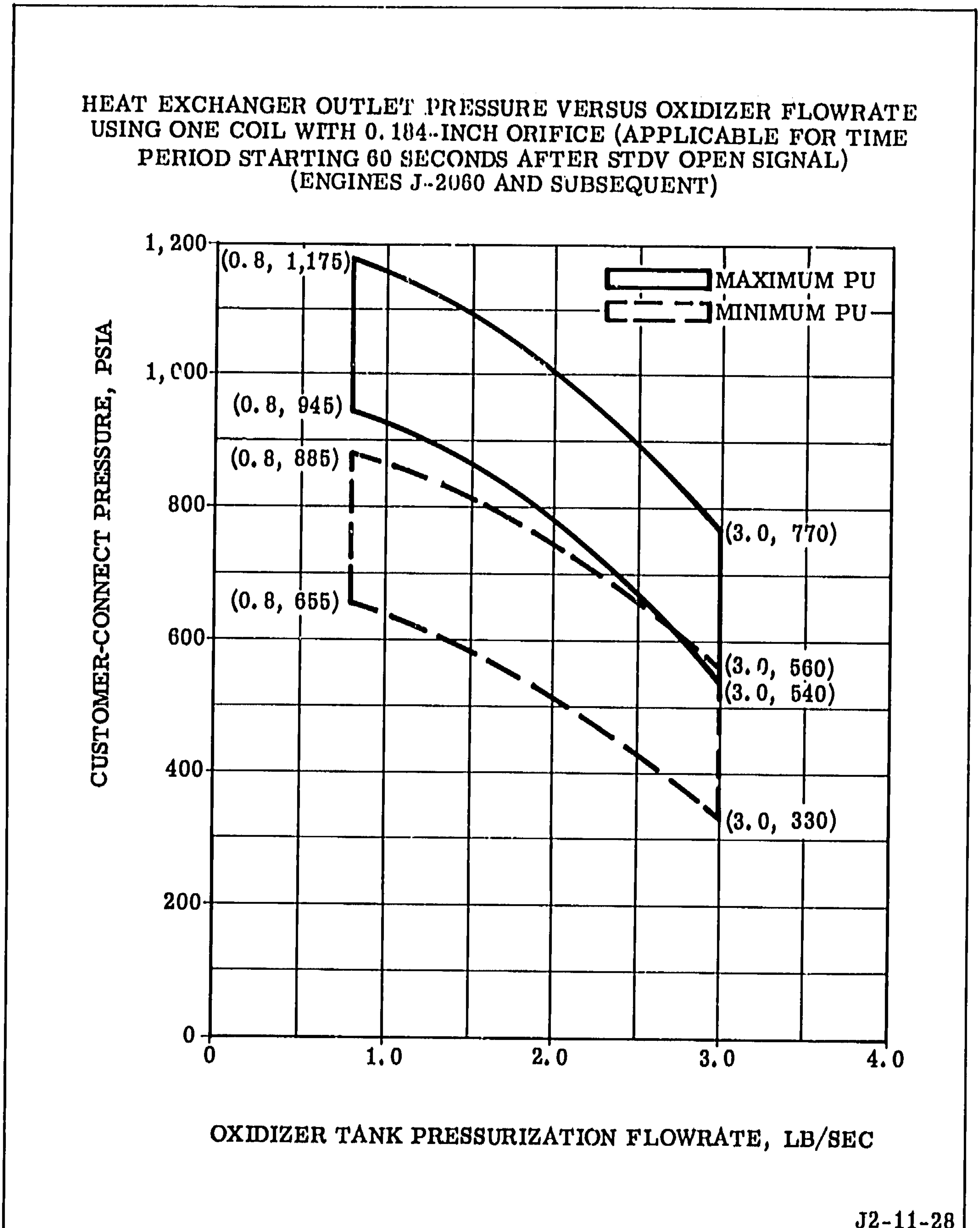
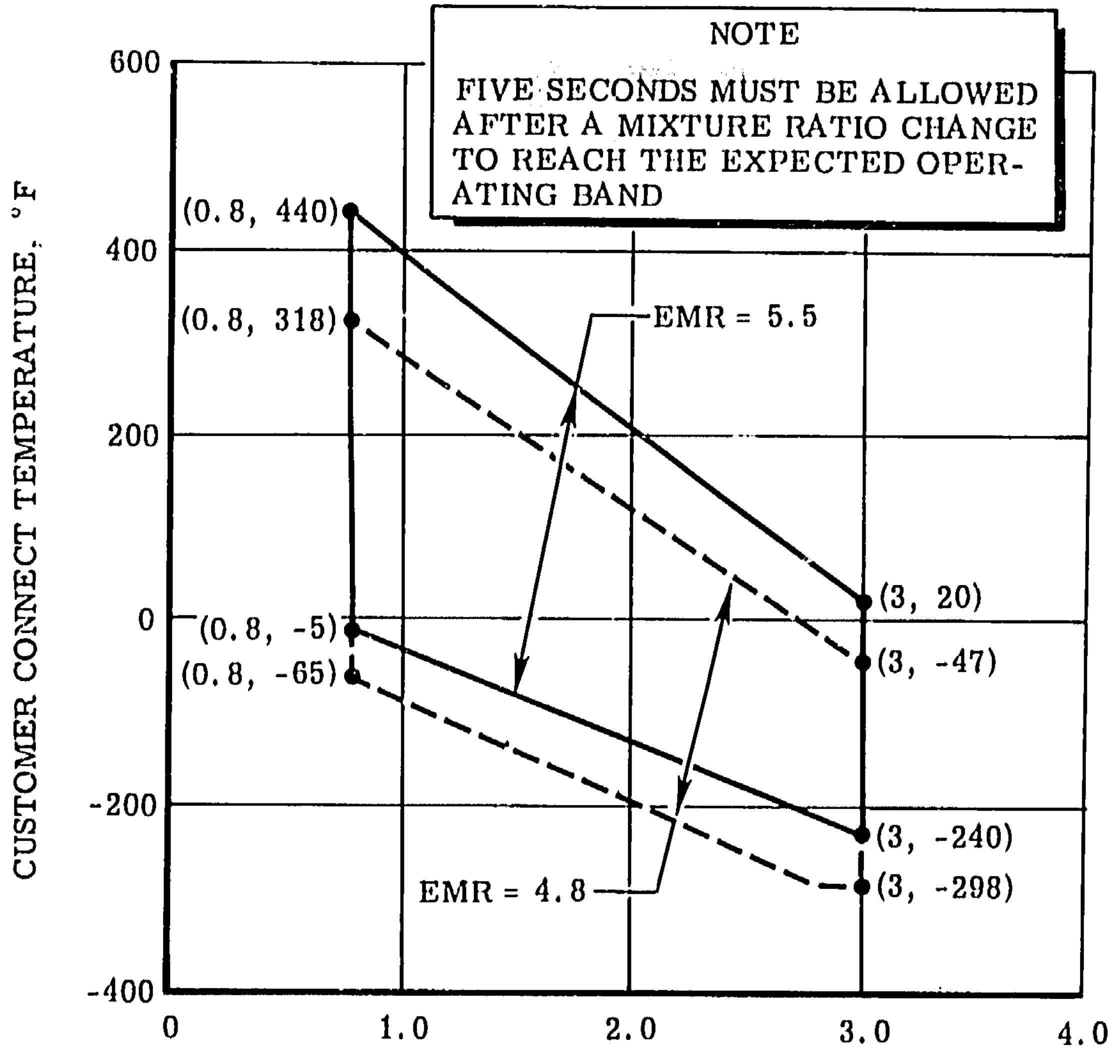


Figure 2-14. Heat Exchanger Oxidizer Output Conditions (SII Stage Engines Not Incorporating MD371 Change) (Sheet 6 of 6)

HEAT EXCHANGER OUTLET TEMPERATURE VERSUS OXIDIZER FLOWRATE USING ONE COIL WITH 0.184-INCH ORIFICE (APPLICABLE FOR TIME PERIOD FROM 10-60 SECONDS AFTER STDV OPEN SIGNAL



J2-1B-45

Figure 2-14A. Heat Exchanger Oxidizer Output Conditions (SII Stage Engines Incorporating MD371 Change) (Sheet 1 of 4)

HEAT EXCHANGER OUTLET TEMPERATURE VERSUS OXIDIZER FLOWRATE USING ONE COIL WITH 0.184-INCH ORIFICE (APPLICABLE FOR TIME PERIOD STARTING 60 SECONDS AFTER STDV OPEN SIGNAL)

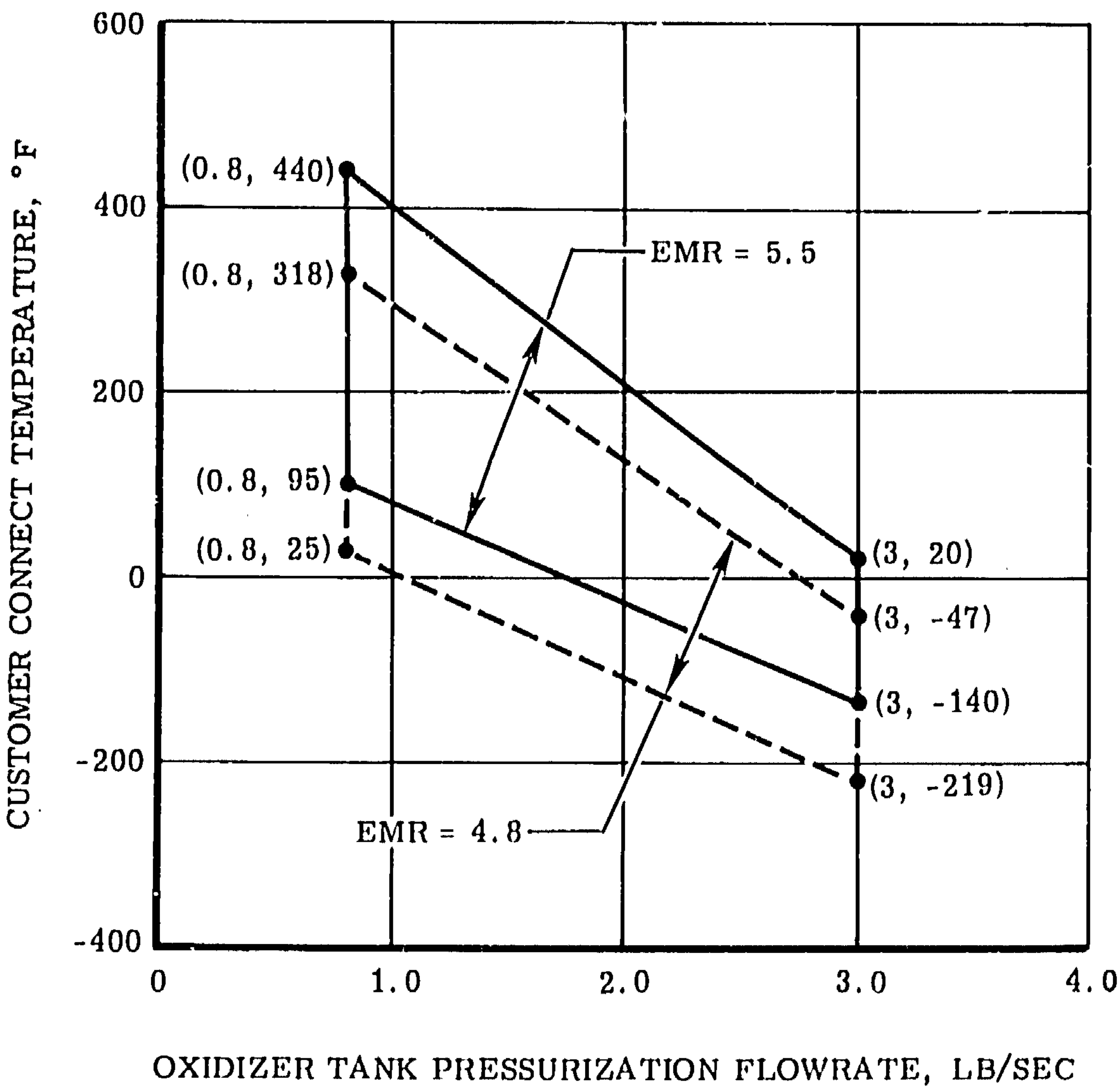


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Figure 2-14A. Heat Exchanger Oxidizer Output Conditions (SII Stage Engines Incorporating MD371 Change) (Sheet 2 of 4)

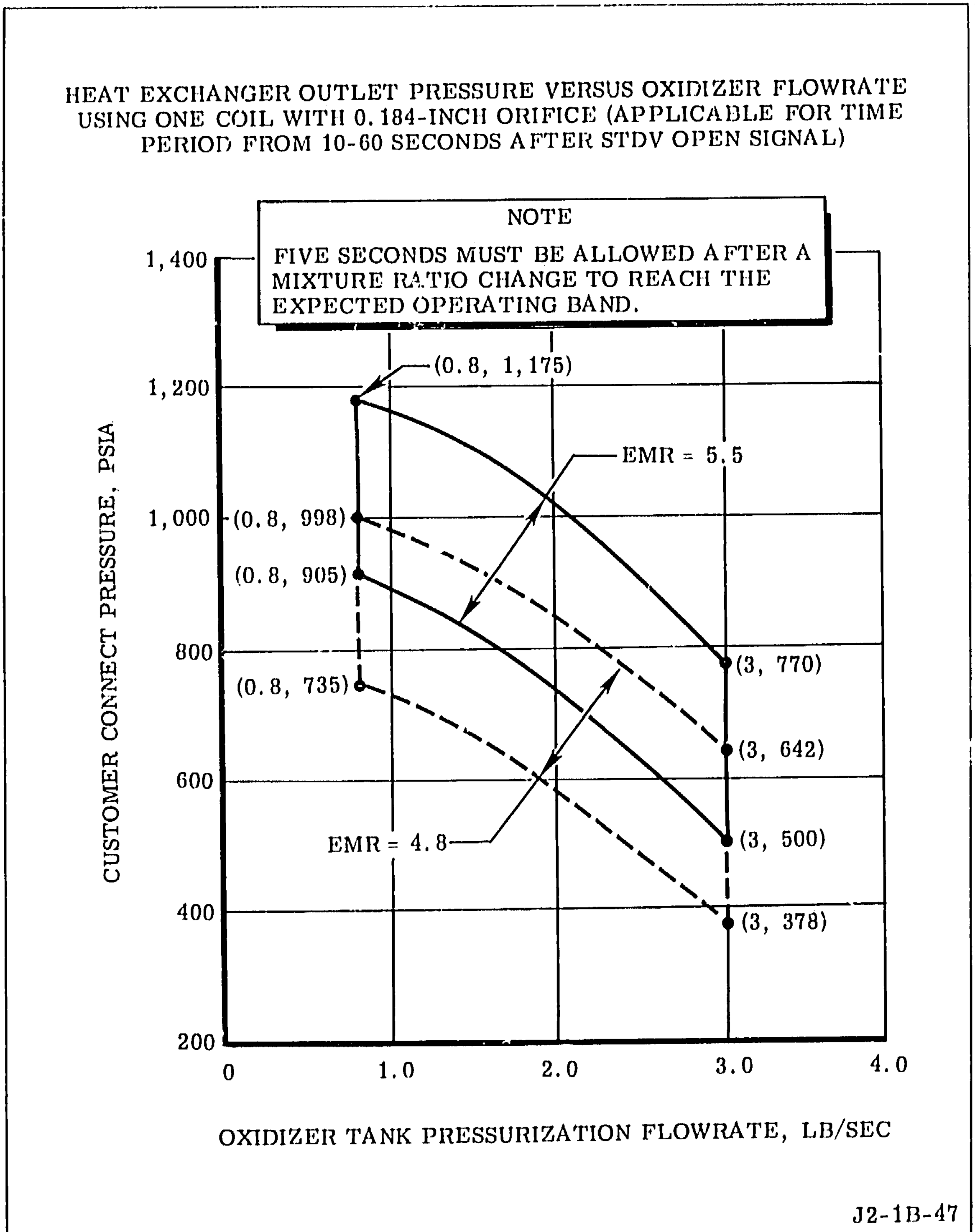
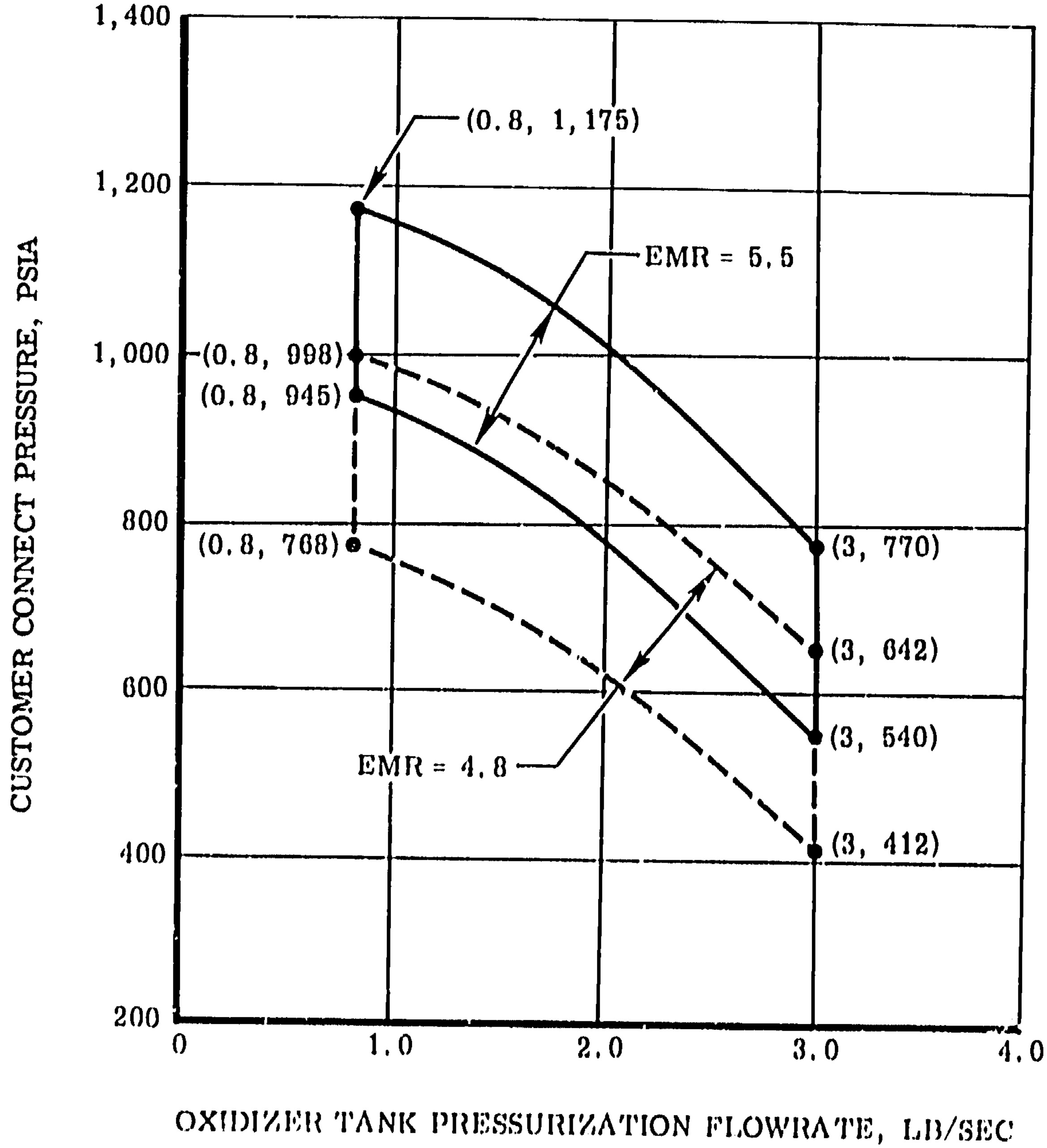


Figure 2-14A. Heat Exchanger Oxidizer Output Conditions (SII Stage Engines Incorporating MD371 Change) (Sheet 3 of 4)

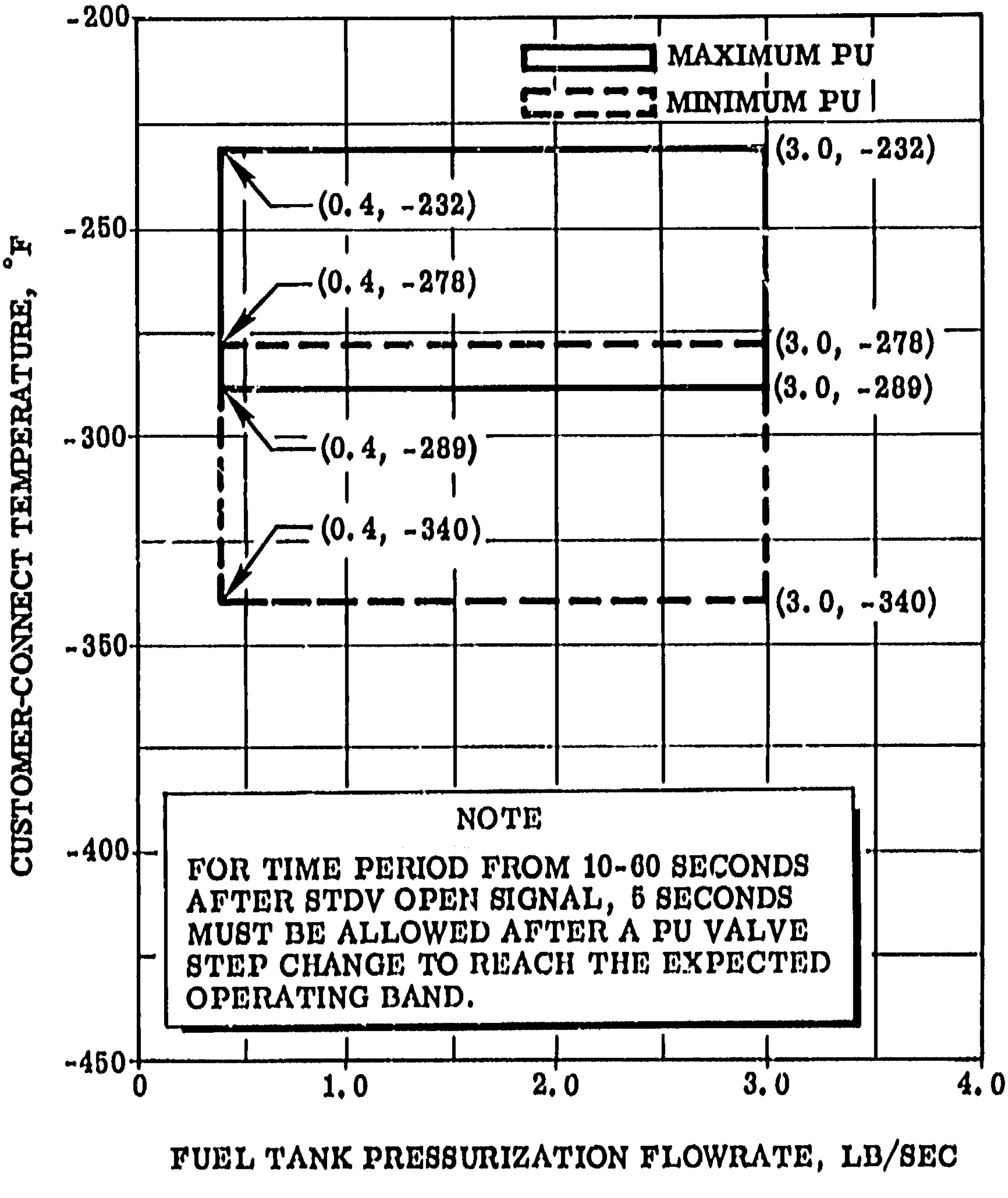
HEAT EXCHANGER OUTLET PRESSURE VERSUS OXIDIZER FLOWRATE USING ONE COIL WITH 0.184-INCH ORIFICE (APPLICABLE FOR TIME PERIOD STARTING 60 SECONDS AFTER STDV OPEN SIGNAL)



J2-1B-48

Figure 2-14A. Heat Exchanger Oxidizer Output Conditions (SII Stage Engines Incorporating MD371 Change) (Sheet 4 of 4)

FUEL TANK PRESSURIZATION TEMPERATURE VERSUS FLOWRATE



NOTE

FOR TIME PERIOD FROM 10-60 SECONDS AFTER STDV OPEN SIGNAL, 5 SECONDS MUST BE ALLOWED AFTER A PU VALVE STEP CHANGE TO REACH THE EXPECTED OPERATING BAND.

Figure 2-15. Fuel Tank Pressurization Conditions (Engines Not Incorporating MD366 or MD371 Change) (Sheet 1 of 3)

FUEL TANK PRESSURIZATION PRESSURE VERSUS FLOWRATE
(ENGINES J-2025 THROUGH J-2059)

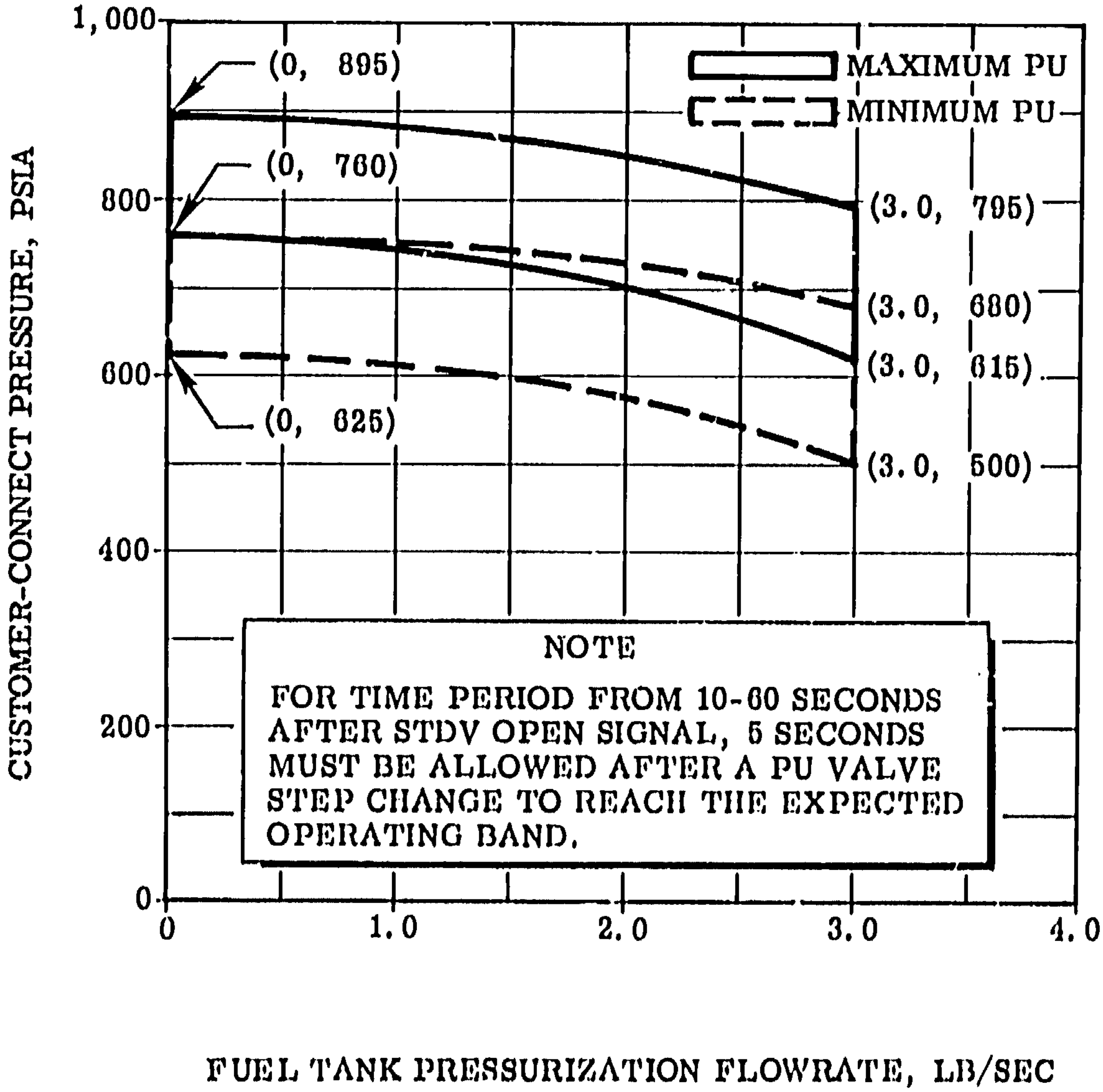


Figure 2-15. Fuel Tank Pressurization Conditions (Engines Not Incorporating MD366 or MD371 Change) (Sheet 2 of 3)

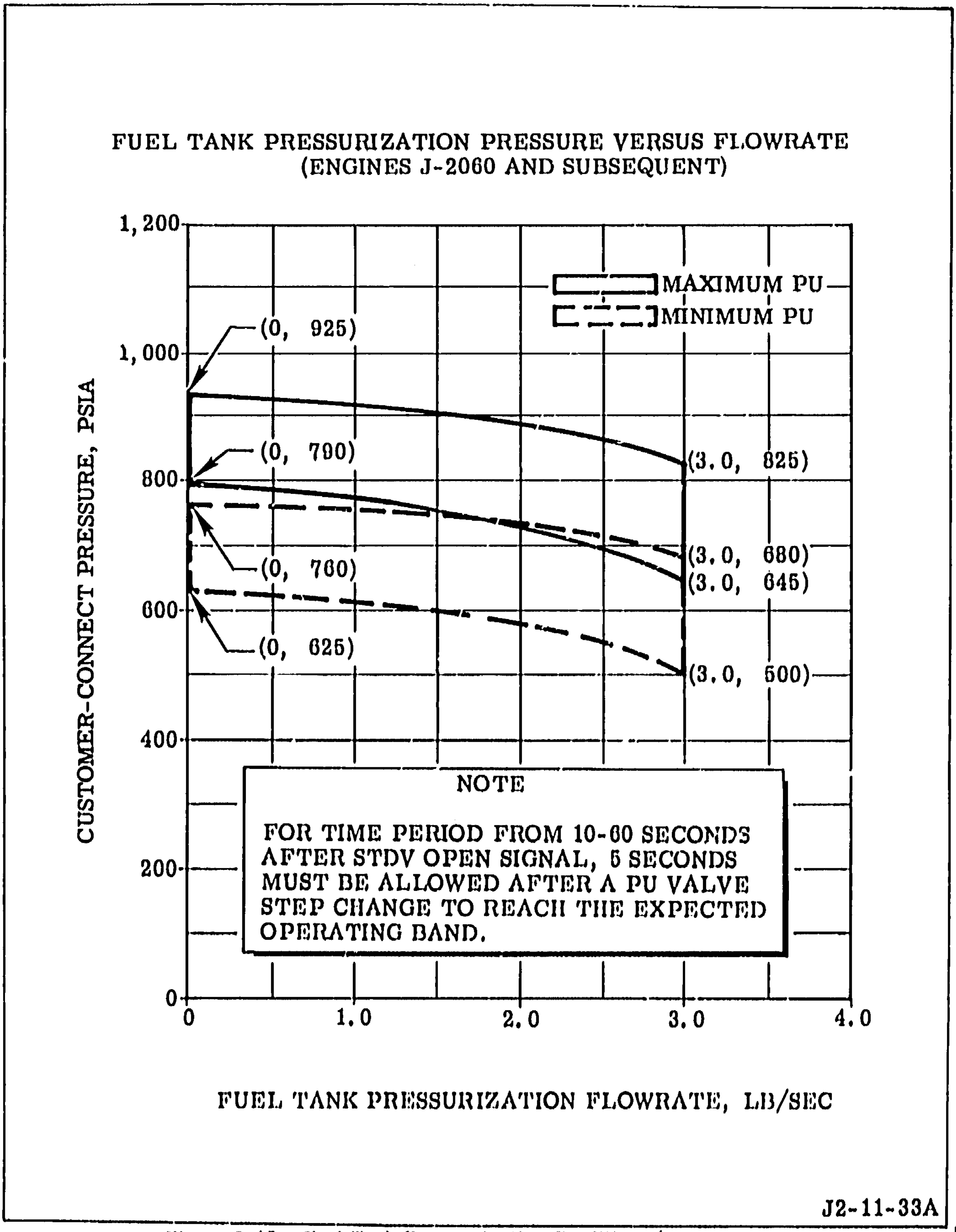


Figure 2-15. Fuel Tank Pressurization Conditions (Engines Not Incorporating MD366 or MD371 Change (Sheet 3 of 3)

2.2 ELECTRICAL REQUIREMENTS.

2.2.1 AC POWER REQUIREMENTS.

2.2.1.1 Ground Checkout Requirements. AC power required during checkout for obtaining electrical simulation on the pump speed transducers and main propellant flowmeters are as follows:

a. Maximum of 0.2 watt for each coil during period of simulation of 10 vac, single phase, 200 ±0.2 Hz, for flowmeter pickup simulation.

b. Maximum of 0.2 watt during period of simulation at 10 vac, single phase, 5,850 ±5 Hz, for fuel pump speed transducer simulation.

c. Maximum of 0.2 watt during period of simulation at 10 vac, single phase, 1,920 ±2 Hz, for oxidizer pump speed transducer simulation.

2.2.2 DC POWER REQUIREMENTS.

a. Control power: 360 watts maximum (at 30 vdc) for electrical control circuits and solenoids during start and powered flight, 24-31 vdc during engine start and 22-31 vdc after mainstage operation is achieved.

b. Ignition power: 600 watts maximum (at 30 vdc) for a maximum of 12.0 seconds for ignition of ASI spark plugs and GG spark plugs at 24-31 vdc.

c. At initial voltage application, voltage may be 32 vdc maximum for a period not to exceed 60 seconds.

d. Primary instrumentation system power:

(1) Pressure transducers: 24 watts maximum (at 32 vdc) with a voltage range of 24-32 vdc and 1.54 additional watts for each transducer undergoing electrical simulation during the period of electrical simulation.

(2) Valve potentiometers: 0.50 watt maximum, continuous at 5 vdc.

(3) Valve position switches: 2.0 watts maximum at 32 with a range of 24-32 vdc for each closed switch.

(4) Temperature transducer power depends on stage circuitry.

e. Auxiliary instrumentation system power pressure transducers require 46 watts maximum (at 32 vdc) with a voltage range of 24-32 vdc and 1.54 additional watts for each transducer undergoing electrical simulation during the period of electrical simulation.

f. The dc peak ripple voltage must not exceed 2.1 volts for the engine control system and 0.1 volt for the instrumentation system when measured with a peak reading vacuum-tube voltmeter in series with a 4.0-microfarad capacitor. The higher of the two values measured when the voltmeter is successively connected for each of the two polarities must be considered the ripple voltage. The maximum voltage transient limits must be a 50-volt positive pulse with a time width of 10 microseconds and a repetition rate of 20 pulses per second.

2.2.3 PROPELLANT UTILIZATION VALVE ELECTRICAL REQUIREMENTS (ENGINES NOT INCORPORATING MD366 OR MD371 CHANGE).

a. Servomotor fixed phase (SIVB stage): 108-121 vac rms, 394-410 Hz, 35 watts maximum at 121 vac rms and 394 Hz; power factor, 0.30 to 0.70; maximum current, 0.600 ampere rms.

b. Servomotor fixed phase (SII stage): 108-121 vac rms, 394-410 Hz, 35 watts maximum at 121 vac rms and 394 Hz; power factor, 0.30 to 0.70. The maximum current is 0.600 ampere rms. The Stage Contractor must make sure that the combination of the five PU valve current values on each stage does not exceed the capability of the PU computer. When a current measurement is obtained with the valve at ambient temperature, use the following relationship to determine the cold valve current:

$$I_{fc} = (R_t - R_1)(0.00859) - 0.106 + I_{fm}$$

where

I_{fc} = cold fixed-phase current (amperes)

R_t = measured control-phase resistance (ohms) at I_{fm} current

R_1 = measured test load resistance (ohms)

I_{fm} = measured fixed-phase current (amperes)

c. Servomotor control phase: 40 vac rms maximum, 394-410 Hz, 16 watts maximum at 40 vac rms and 394 Hz; power factor, 0.30 to 0.70: maximum current, 0.800 ampere rms (based on not using center tap).

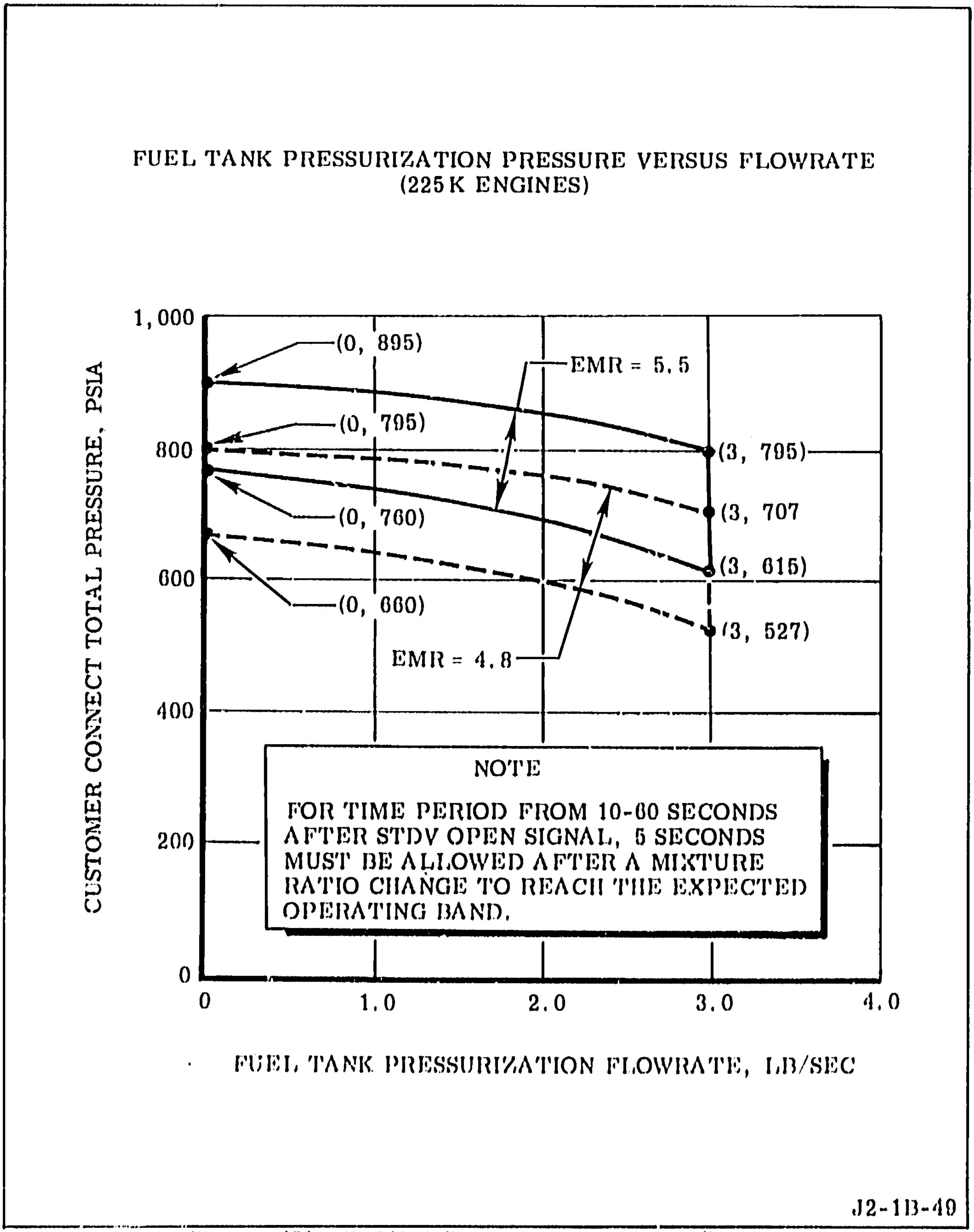
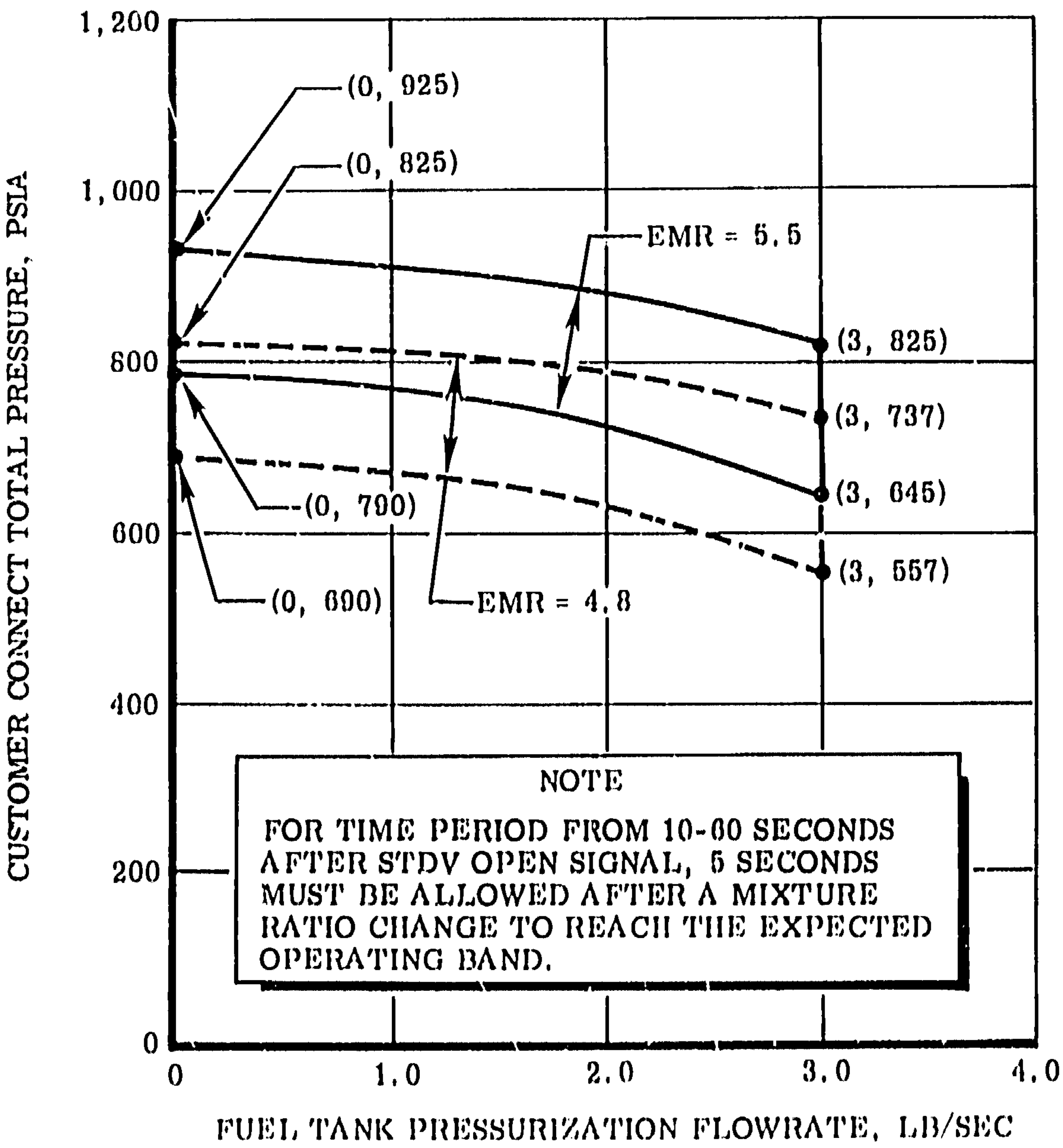


Figure 2-15A. Fuel Tank Pressurization Conditions (Engines Incorporating MD371 Change) (Sheet 1 of 3)

FUEL TANK PRESSURIZATION PRESSURE VERSUS FLOWRATE
(230K ENGINES)



J2-1B-50

Figure 2-15A. Fuel Tank Pressurization Conditions (Engines Incorporating MD371 Change (Sheet 2 of 3)

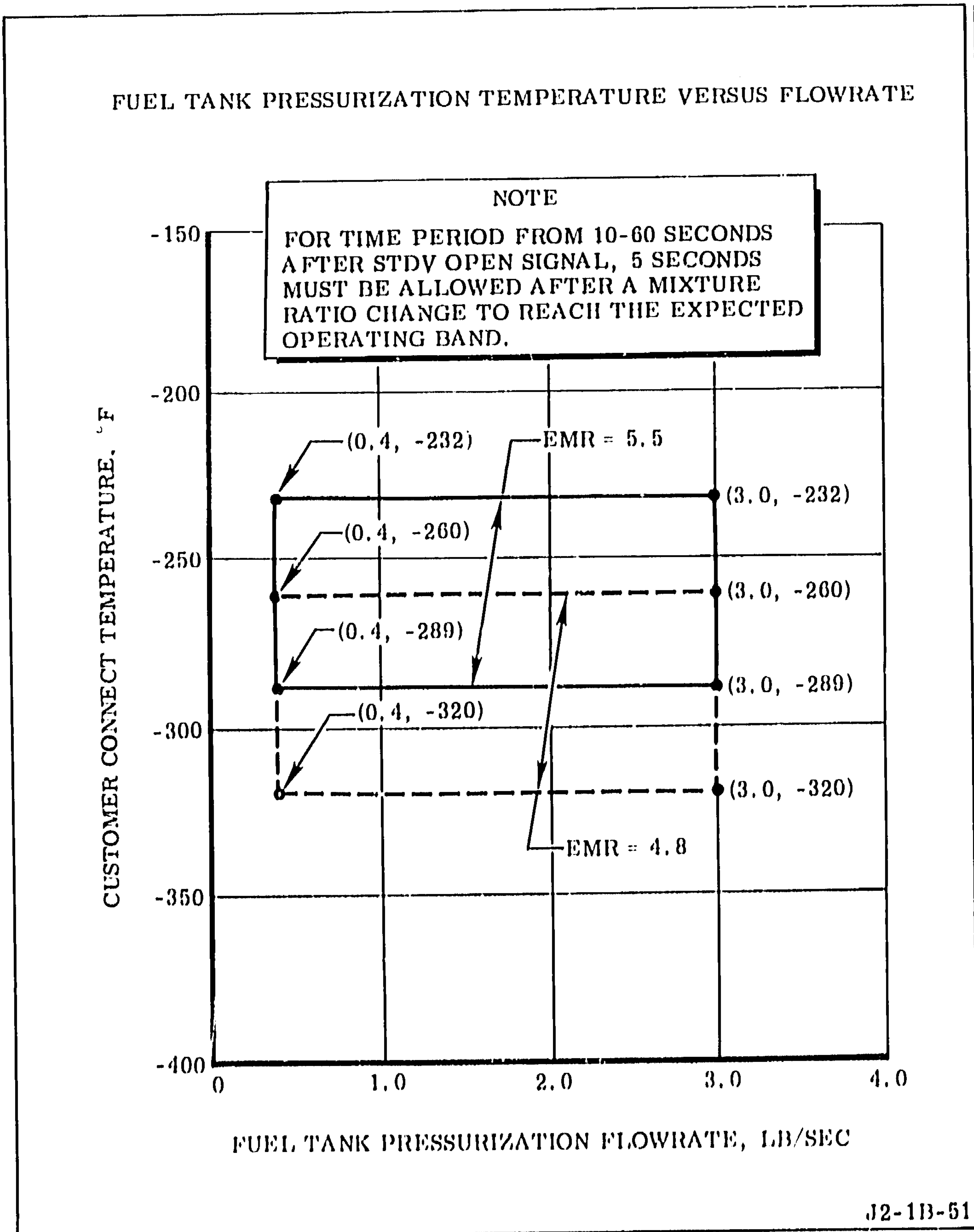


Figure 2-15A. Fuel Tank Pressurization Conditions (Engines Incorporating MD371 Change) (Sheet 3 of 3)

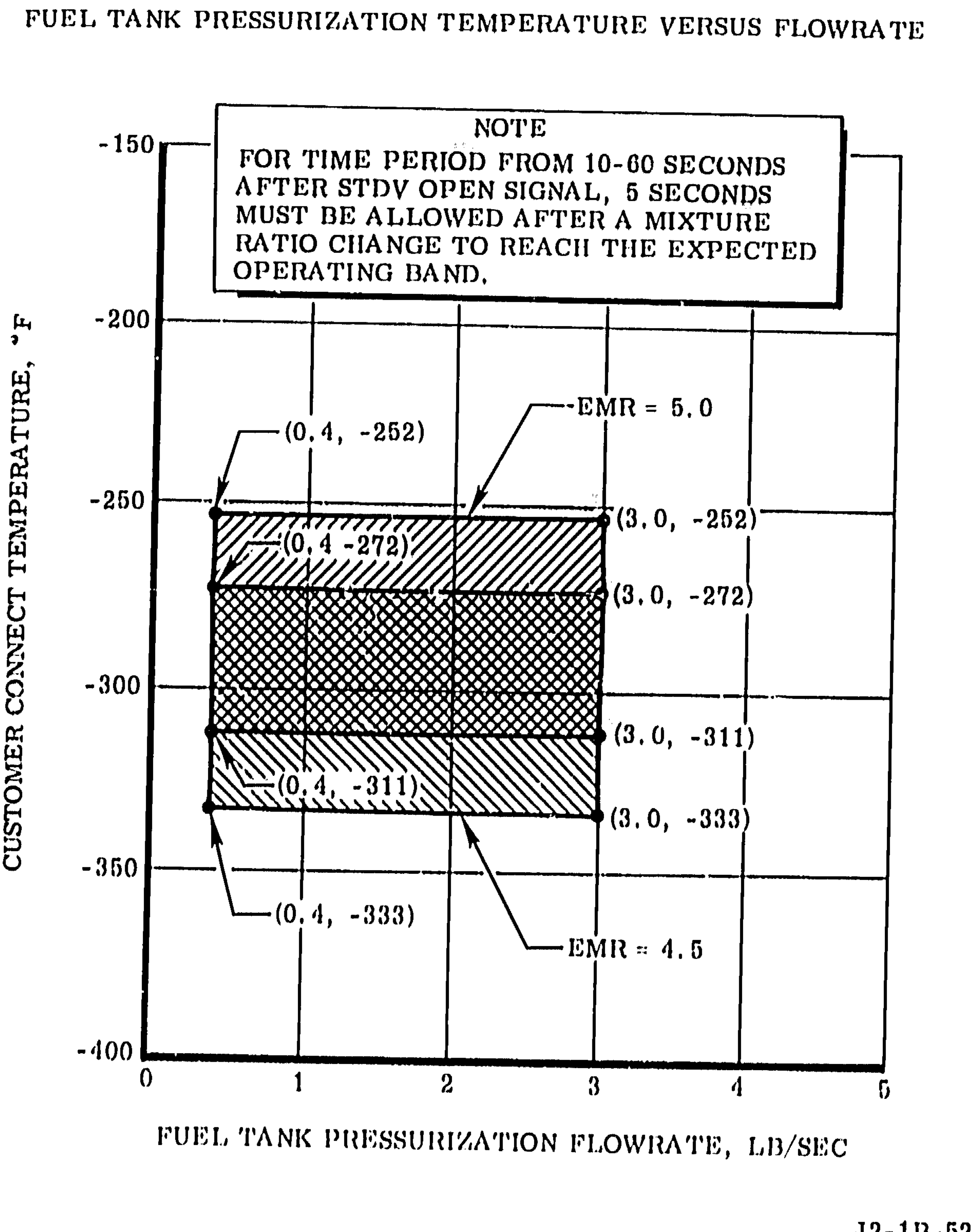


Figure 2-15B. Fuel Tank Pressurization Conditions (Engines Incorporating MD366 Change) (Sheet 1 of 2)

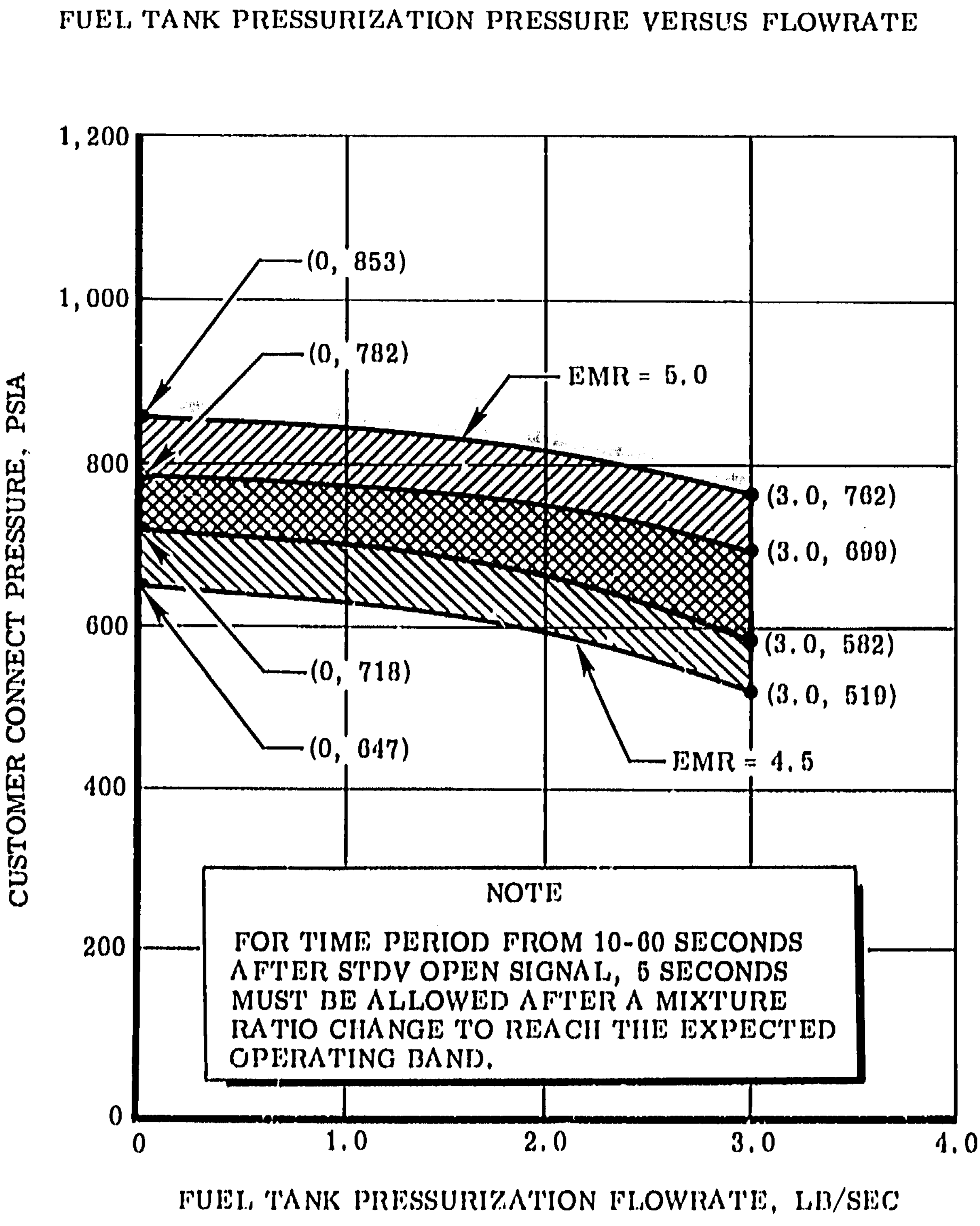


Figure 2-15B. Fuel Tank Pressurization Conditions (Engines Incorporating MD300 Change) (Sheet 2 of 2)

NOTE

The center tap of the control-phase winding is located 38 turns from either end of the winding, and each half of the control-phase winding must have a dc resistance of 8.2 (±10 percent) ohms at 68° F.

d. Phase relationship (electrical connector P38): For valve closing, fixed-phase voltage on pin R with respect to pin P leads control-phase voltage on pin C with respect to pin E. For valve opening, fixed-phase voltage on pin R with respect to pin P lags control-phase voltage on pin C with respect to pin E.

e. Listed voltages are rms values based on sinusoidal waveforms. One of the applied voltages may be nonsinusoidal. If a nonsinusoidal waveform is applied to the servomotor, the waveform must be passed through a wave analyzer, the fundamental sinusoid must meet the voltage requirements, and the phase relationship applies to the fundamental sinusoid.

f. With the PU valve stalled, the required control-phase voltage must be determined by the following relationship:

$$V_c = \frac{115}{V_f}\left(\frac{V_T + 8.4}{-0.236 + 0.0276\phi - 0.000155\phi^2}\right)$$

where

V_c = control-phase voltage

V_T = measured PU valve maximum threshold voltage

V_f = measured fixed-phase voltage

ϕ = measured-phase relationship in degrees between the fixed-phase voltage and the control-phase voltage with the PU valve stalled

The Stage Contractor establishes whether or not the available computer voltage is greater than the calculated Vc for the PU valve. If the available computer voltage is not greater than the calculated Vc for the PU valve, NASA will determine the required action. The extent of the possible incompatibility is limited by the following:

(1) The available computer voltage ($V_c \sin\phi$) must be a minimum of 15 vac for the PU valve by the above equation.

(2) The required PU valve threshold voltage (V_T) must be a maximum of 15.1 vac. For PU valves tested as a component (not installed on an engine) after 24 April 1969, the required PU valve threshold voltage (V_T) is a maximum of 12.0 vac.

g. Steps e and f apply at all motor operating temperatures that may vary between +300° and -50° F as determined by measuring control-phase winding resistance. Power must not be applied to the motor if protective covers or insulation is on the valve actuator, except insulation installed by Rocketdyne drawings or Modification Instructions. Without liquid oxygen in the valve, operation may be programmed concurrently with power on. Before loading cryogenics, power must be applied to the fixed phase and the valve positioned to null for 0.50 hour minimum. With the PU valve closed, the resistance between connector P38 (pins J and K) and connectors P105 (pin D) and P107 (pin e) must have minimum resistance. With the PU valve open, the resistance between connector P38 (pins K and L) and connectors P107 (pin e) and P107 (pin E) must have minimum resistance.

h. Valve response: Given a step command, the valve must travel stop-to-stop (60±2 degrees) within 2.25 seconds maximum when the voltage and phase relationship of the expression

$$V_c = \frac{115}{V_f}\left(\frac{V_T + 8.4}{-0.0236 + 0.0276\phi - 0.000155\phi^2}\right)$$

is available (if required by the PU valve motor).

i. Feedback potentiometer: resolution 0.15 percent minimum; linearity ±0.50 percent from best straight line.

j. Gearing backlash:

(1) Power gear train (motor-to-valve gate); with motor pinion gear locked, valve gate assembly backlash must not exceed one degree of arc.

(2) Potentiometer gear train (valve gate to potentiometer); with potentiometer pinion gear locked, valve gate assembly backlash must not exceed 0.50 degree of arc.

2.2.3A MIXTURE RATIO CONTROL VALVE ELECTRICAL REQUIREMENTS (ENGINES INCORPORATING MD360 OR MD371 CHANGE).

a. Power: 21-31 vdc and a maximum of 93 watts when commanded to the low EMR position.

b. Solenoid arc suppression: provided by Stage Contractor.

2.2.4 SPARK IGNITER SYSTEM REQUIREMENTS. The redundant high-tension spark ignition system is required to establish ignition in the GG and thrust chamber.

CAUTION

Component and sequence tests of the engine must be scheduled in accordance with the spark exciter duty cycle. Exceeding the operating time or repeating operations without the prescribed cool-off time can damage the spark exciters and require replacement of the ECA.

a. Duty cycle constraints: The spark exciters are designed for a duty cycle of 10 seconds on and 5 minutes off or 5 seconds on and 3 minutes off. This off-time interval must be observed when performing any sequence of engine tests in which the spark igniters are energized, to avoid exceeding the recommended duty cycle.

b. Operating specifications: During engine static testing, Spark Monitor/Overspeed Cutoff Panel G1045 monitors the interval between successive sparks and requires that the interval be 25 milliseconds or less throughout the first half-second before giving a spark OK indication. If a no-go signal is received, review oscillograph data from spark monitor. The spark rate must average a minimum of 40 sparks per second for each second of operation, and there must be no more than 30 milliseconds between any two sparks. A maximum spark rate is not specified because the maximum value is not critical to engine operation.

2.3 ENVIRONMENTAL REQUIREMENTS.

2.3.1 ENGINE ENVIRONMENTAL CONDITIONS. The engine must be dry and stored, to preclude exposure to rain, sand, dust, etc, and with the thrust chamber longitudinal axis in a vertical or horizontal position. The ambient temperature of the engine environment must be within -20° to +140° F except when the engine is stored in the environment specified in the MSFC-STD-406 or MSFC-STD-408. During engine handling, with the engine installed in Engine Contractor authorized handling equipment, the engine must not be exposed to acceleration loads exceeding 4g in any direction. All parts of the engine that require protective closures or covers must be protected at all times unless otherwise indicated by the applicable procedures or requirements in this manual or by MSFC-STD-406 or MSFC-STD-408. Transport components or assemblies requiring rework or inspection to an environmentally controlled area before removing protective closures and/or covers.

2.3.2 DESICCANT ENVIRONMENTAL CONDITIONS. The J-2 engine closures require desiccant RB0295-001 (Rocketdyne) packaged in dust-free, high-burst-and-tear-strength plastic bags. Desiccant used in engine closures must not be reactivated. Packaged desiccant may be obtained in various unit sizes ranging from fractional units of 1/16, 1/3, and 1/2 to sizes of 1, 2, 4, 8, and 16 units and may be used in any combination.

2.3.2.1 Desiccant Storage. Desiccant must be stored in a sealed metal container having an airtight door and an externally mounted humidity indicator with an indicating element capable of monitoring 20 percent relative humidity, or less. A caution must be stenciled directly on the exterior of the container stating: "This container contains moisture-absorbent desiccant. Do not open container except to remove desiccant. Reseal immediately. Take only the quantity required for immediate use." If more than one size of desiccant is stored in a container, segregate units by packaging each size in separate plastic bags. The plastic bags may be closed in any manner that will provide ready access to the desiccant and that will eliminate the possibility of physical damage to desiccant bags. The relative humidity in the storage container must be maintained at less than 20 percent relative humidity. If the 20-percent spot on the storage container turns a color other than blue, the entire contents of the storage container must be replaced with a new supply of desiccant. Desiccant removed from the storage container and not installed and sealed in a closure within a maximum of 5 minutes, may be stored outside the container for a maximum of one hour if the desiccant is placed in a polyethylene bag (6-mil minimum thickness). Excess air must be squeezed from the bag and the open end of the bag must be folded, closed, and sealed with tape before the 5 minutes lapse.

2.3.2.2 Desiccant Installation. Desiccant must be stored as outlined in paragraph 2.3.2.1 until immediately before installation. The time phase between removal of desiccant from storage and sealing in a protective closure must not exceed 5 minutes, or desiccant must be discarded. Desiccant bags must be handled carefully to prevent tearing or rupturing the bags. Immediately before installing desiccant in a closure, the desiccant bag must be wiped with a clean, hemmed, nylon cloth moistened with cleaning compound (MIL-C-81302). The quantity of desiccant used in a particular closure is as

stated on the closure. Specific requirements for desiccant in relation to the engine is as follows:

WARNING

Cleaning compound (MIL-C-81302) is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

a. When desiccant in an engine closure is replaced, inspect closure humidity indicator after 24 hours. If 30-percent humidity range spot shows color other than blue, replace desiccant and repeat inspection after 24 hours. This inspection and desiccant replacement cycle may be repeated a maximum of five times before trouble analysis must be performed.

b. When desiccated protective closures are removed from engine, compare number of bags and units with number recorded and account for all desiccant before processing hardware. Note condition of bags. If hardware contamination is suspected as a result of discrepant bags, verify condition of processing hardware.

c. Replace desiccant each time desiccated closures are removed for more than 5 minutes unless desiccant or closure with installed desiccant is immediately placed in a desiccant storage container as outlined in paragraph 2.3.2.1.

d. When the engine diffuser is installed, desiccant is not required in the thrust chamber exit closure. After engine diffuser is removed, the quantity of desiccant specified on closure must be installed.

2.4 MAINTENANCE REQUIREMENTS.

2.4.1 SEAL USAGE. Seals from connections that have been disassembled must be replaced with like-serviceable items when a visual inspection reveals contaminants, nicks, scratches, or any other defect that may impair sealing capability. When a joint is opened, pressure-actuated Naflex seals must be replaced. Removed Naflex seals must be returned to Engine Contractor for disposition.

2.4.2 FASTENER USAGE. Bolts removed from the engine or components must be replaced when a visual inspection reveals damage to the bolthead, grip, threads, plating, or dry-film lubricant. Undamaged bolts may be reused unless otherwise specified. Nuts may be reused if threads and wrench flats are not damaged. Self-locking nuts may be reused if the locking feature still provides positive torque drag. Washers are reusable as long as the plating is not damaged and the surfaces are not deformed. Any engine fastener disturbed during performance of authorized activities must be retorqued to its applicable torque value at the completion of that activity. Anytime the flange joint downstream of the GG oxidizer purge check valve is disconnected and reconnected, the 4 bolts securing the flange must be inspected to make sure that a minimum of one full thread protrudes beyond top of nut.

2.4.3 FASTENER CROSS-TORQUE REQUIREMENT. The cross-torquing method must be used for multifastener application of flanges or joints, to apply evenly distributed axial loads to seals and gaskets. Torque must be applied in increments of one third of the total torque to be applied until all fasteners are evenly torqued to the desired torque value.

2.4.3A. CONDITION AND SECURITY OF JOINTS. Before connecting a joint, the condition of the seal, sealing surfaces, and joint fasteners must be inspected. The seal and sealing surfaces of a joint must be free of foreign particles, nicks, scratches, and other imperfections that could impair sealing capability. The threads of a joint fastener and its mating threads must be free of damage. Installation of the seal, mating of the sealing surfaces, torquing of the fasteners, and safetywiring of the joint fasteners must be inspected and inspection recorded when mating of a joint is required in applicable paragraphs of this manual.

2.4.4 DAMAGE DISPOSITION. All damage to the engine, regardless of the magnitude or nature of the discrepancy, must be considered as either one of the following conditions:

a. Acceptable without repair if within the acceptable damage limits specified in figures 1-3, 1-4, and 1-5.

b. Not acceptable without repair or further evaluation to determine an appropriate disposition. This type of damage is identified in section I by the entry "Damage is not allowable." Generally, this applies to damage for which no acceptable damage limits have been formulated. Each damage occurrence must be evaluated on an individual basis in accordance with the authorized site discrepancy reporting system.

2.4.5 COMPONENT REMOVAL AND INSTALLATION CONSTRAINTS. Authorized and approved procedures and equipment must be used for component removal, replacement, and reinstallation. Field modifications of approved ECPs and inspections by EFIRs may be done at any field location. Removal and reinstallation or replacement of components or assemblies listed in figure 2-16 affects engine performance or alinement. Replacement requires Engine Contractor Engineering analysis and NASA EPO approval. Components or assemblies not listed in figure 2-16 may be removed, reinstalled, or replaced without affecting engine performance or alinement.

Component or Assembly	Removed and Reinstalled	Replaced
Thrust chamber assembly	(a)	(a) and (b)
Thrust chamber injector assembly	(a)	(a) and (b)
Heat exchanger		(b)
Gimbal bearing	(a)	(a)
Oxidizer turbopump		(b)
Fuel turbopump		(b)
Propellant or hot-gas system orifices		(b)
GG injector oxidizer poppet assembly		(b)
GG oxidizer supply line		(b)

(a) Affects engine alinement.
(b) Affects engine performance.

Figure 2-16. Component Removal, Reinstallation, and Replacement Constraints

2.4.6 LOCKWIRE REPLACEMENT. Lockwire removed for authorized activities must be replaced at completion of those activities.

2.4.7 COVER AND CLOSURE REQUIREMENT. All parts of the engine requiring protective covers or closures must be protected at all times unless covers are required to be off for an authorized activity.

a. Install suitable protective closures and/or covers on components and assemblies immediately after removal from engine.

b. Install suitable protective closures and/or covers on joints of engine where a component or assembly is removed, immediately after removal.

c. Do not remove protective closures and/or covers from components, assemblies, or engine joints until immediately before installation of components and assemblies on engine.

d. Tape alone does not constitute an engine closure. Do not use tape in direct contact with engine mating surfaces, fluid surfaces, or on threads.

e. Do not use damaged covers and closures on the engine.

2.4.8 ENGINE SOFT GOOD VERIFICATION. An age-control log for component synthetic rubber is provided in each Engine Log Book, listing the replacement dates for all synthetic rubber parts used in the engine. The replacement date is the installation date of the synthetic rubber part plus 40 quarters. If it becomes necessary to replace snythetic rubber parts, the replacement date must be recorded in the Engine Log Book.

2.4.9 ENGINE ORIFICE VERIFICATION. Engine valve timing orifices, as recorded in each Engine Log Book, must agree with the external identification of each orifice installed in the

engine. In case of conflict between the orifice diameter, as recorded in the Engine Log Book, and the external identification of an orifice, the orifice must be removed from the engine and the orifice diameter measured. If the actual orifice diameter differs from that recorded in the Engine Log Book, Engine Contractor Field Engineering must be notified for disposition.

2.4.10 CLEANNESS REQUIREMENT FOR EXTERNAL CONNECTIONS. All components and lines that transfer fluids to engine systems must meet cleanness requirements of engine system hardware before connection to the engine system.

2.4.11 SYSTEM INTERCONNECTION CONSTRAINTS. Systems that transfer fluids to the engine must be identified and/or plumbed, unless otherwise specified, so that fluids cannot intermix or systems cannot be inadvertently interconnected.

2.4.12 HARDWARE ATTACHMENT CONSTRAINTS. Engine Contractor concurrence must be obtained before any additional lines, brackets, clamps, or other hardware is attached to the engine. Attaching additional lines, brackets, clamps, or other hardware to the engine without Engine Contractor analysis may result in reduced engine reliability.

2.4.13 VENT PORT CHECK VALVE REPLACEMENT CONSTRAINTS. Removed vent port check valves that are to be replaced, must be low-temperature tested and vacuum dried before being returned to stock. When a vent port check valve is replaced, it must be verified that the replacement valve has been low-temperature tested, vacuum dried, and the required preinstallation testing has been accomplished.

2.4.14. EQUIPMENT, TOOLS, AND MATERIAL USAGE CONSTRAINTS. All ground support equipment and special tools used on the engine must be complete, undamaged, and meet the engine system cleanness requirements. Ground support equipment and special tool description, operation, and maintenance information is in R-3825-5. All materials used on the engine must be compatible with the applicable engine system and conform to those listed in the procedures.

2.5 OPERATIONAL REQUIREMENTS.

2.5.1 SAFETY DIRECTIVES. The instructions in this manual are the minimum requirements necessary to assure safety of personnel and prevent damage to equipment.

2.5.1.1 Use of Precautionary Notes. Throughout this manual, Caution and Warning notes are used to emphasize important or critical instructions when working with potentially dangerous materials or conditions. These precautionary notes are used to direct attention to the following conditions:

a. Warning: An operating procedure that, if not strictly observed, can result in personal injury or death.

b. Caution: An operating procedure that, if not strictly observed, can result in damage to equipment or hardware.

2.5.2 SAFETY REQUIREMENTS FOR PRESSURIZED SYSTEMS. A pressurized system includes the engine components that are pressurized, the support equipment that provides and controls the pressure, and all interconnecting plumbing.

a. Make sure each system to be pressurized is equipped with a pressure relief device, to prevent system overpressurization. Make sure there is no valve or other shutoff device between the relief device and the system under test.

b. Before engaging in any pressure testing, post pressure-test-in-progress warnings.

c. Do not leave controls unattended when a system is pressurized.

d. Make sure test equipment hoses or lines are depressurized before disconnecting.

e. Secure all test hoses connected between test equipment or facility and/or engine, to prevent hoses from whipping in event of accidental disconnection or line failure.

f. Wear safety glasses or face shield when working in areas where systems are pressurized.

g. When one or both of the following conditions exist, make sure personnel stand behind safety barriers or at a safe distance from engine:

WARNING

Failure to observe this requirement can result in injury to personnel.

(1) More than 1,600 psig is supplied to engine helium tank.

(2) More than 250 psig is supplied to engine helium tank, and engine helium control valve is energized. (Not required at KSC)

2.5.2.1 Safe Test Pressure Requirements for J-2 Engine Systems. The following pneumatic system safe operating pressure requirements are mandatory when personnel are in the area. These safety limits are applicable to the pneumatic actuation portion of valves in the pneumatic system and must be observed at sites that have a restriction on pressure values over 1/4 calculated burst pressure. When the pneumatic system is pressurized, the safe operating pressure is that of the component in the system with the lowest safe operating pressure. The limiting components in the system are as follows:

Limiting Component	Engine Operating Conditions	Safe Operating Pressure (psig)
Oxidizer and fuel bleed valves	Helium control valve energized	325
Start tank discharge valve	Ignition-phase control valve energized	250
GG control valve	Mainstage control valve energized	250
Pneumatic accumulator	Helium control valve energized	346

2.5.3 SAFETY REQUIREMENTS FOR ELECTRICAL SYSTEMS.

a. Deenergize circuits before working on electrical components or cabling. Electrical power may be applied to the engine during leak test of the ECA if spark exciters and engine control circuits are not energized when the ECA is under vacuum.

b. Before connecting a power source to electrical equipment, place circuit breakers controlling the power source, and all switches on electrical equipment, in off or deenergized position.

c. Do not leave electrical controls unattended when an electrical system is energized.

d. Ground engine and electrical consoles to a common ground with separate ground cables.

2.5.4 SAFETY REQUIREMENTS FOR TOXIC SOLVENTS. The fluids specified for use in this manual are considered to be the least hazardous for the application indicated. The fluids used, associated hazards, and required safety precautions are as follows:

a. Trichloroethylene (MIL-T-27602), trichloroethane (MIL-T-81533), trichloroethane (Federal Specification O-T-620) and equivalent solvents:

(1) Trichloroethylene and trichloroethane must be used in a well-ventilated area, and excessive inhalation of vapors must be avoided. Trichloroethylene and trichloroethane give off vapors even at room temperature, and prolonged inhalation can produce narcotic effects on the nervous system.

(2) Trichloroethylene or trichloroethane must not be allowed to contact skin for prolonged periods since it can be absorbed through the skin. The liquid chemically dries the skin, leaving it susceptible to infection.

(3) Safety glasses or a face shield must be worn while using trichloroethylene or trichloroethane.

(4) A breathing apparatus must be worn while working with trichloroethylene or trichloroethane in confined or unventilated areas.

(5) Trichloroethylene or trichloroethane must not be exposed to excessive temperatures.

b. Cleaning compound (MIL-C-81302) and equivalent solvents:

(1) Cleaning compound must be used in a well-ventilated area, and excessive inhalation of vapors must be avoided since it may cause dizziness, unconsciousness, or suffocation due to the oxygen-deficient atmosphere.

(2) Cleaning compound must not be allowed to contact the skin for prolonged periods. The liquid chemically dries the skin, leaving it susceptible to infection.

(3) Safety glasses or a face shield must be worn when using cleaning compound.

(4) A breathing apparatus must be worn when using cleaning compound in confined or unventilated areas.

(5) Cleaning compound must not be exposed to excessive temperatures.

2.5.5 SAFETY REQUIREMENTS FOR THRUST CHAMBER ENTRY. The following precautions must be observed when entering the thrust chamber to perform inspections associated with static test or launch operations.

a. Prevent inadvertent pressurant or propellant admission into thrust chamber.

b. Wear breathing apparatus when entering thrust chamber.

c. Support ladders used in thrust chamber and use protective padding on ladders, to prevent damaging thrust chamber tubes.

d. Use buddy system when entering the thrust chamber.

2.5.6 REQUIREMENTS FOR GROUND SUPPORT EQUIPMENT AND SPECIAL TOOLS. The ground support equipment and special tools used in the authorized activities in this manual must meet their respective test and inspection requirements before usage. Personnel who operate ground support equipment identified with an operator warning decal, plate, or tag, must be authorized and trained in the use of that equipment. This ground support equipment is identified in Rocketdyne technical manual procedures specifying use of the equipment.

2.5.7 ENGINE SERVICE LIFE. The total operating service life of the engine is 3,750 seconds of mainstage operation. The time period from STDV open control signal to engine cutoff signal is used for recording engine operating time in Engine Log Book.

2.5.8 COMPONENT SERVICE LIFE. The cycle limit of the helium regulator assembly after the incorporation of MD333 change is 2,000 additional cycles. New regulators incorporating MD333 change or regulators reworked with a new diaphragm and incorporating MD333 change have a service life of 5,000 cycles. A cycle is defined as an actuation and deactuation operation of the helium control valve with the helium tank pressurized.

2.5.9 GIMBALING LIMITATIONS. The gimbaling limitation of the customer connect lines and propellant inlet ducts and the gimbaling limitation of the gimbal bearing are shown in figure 2-17. The allowable gimbaling includes cycles accumulated under all conditions of engine usage, such as engine operating or nonoperating, pressurized or nonpressurized, and chilled or nonchilled. A cycle is defined as either (1) gimbaling from null position to a particular angle, then returning through null to the opposite angle and back to null or (2) gimbaling from null position to a corner angle, then around a square gimbal pattern through the other three corner angles, then back to the original corner angle, and (optional) back to null. Any gimbal movement that is less than the defined cycle must be recorded in the Engine Log Book as a half cycle. Figure 2-17 shows the percentage of design life expended for each cycle at a particular angular excursion. The percentage per cycle must be multiplied by the number of cycles at that particular angular excursion to determine the cumulative percent of design life expended. For

square-pattern gimbaling, the number of square-pattern cycles must be multiplied first by 1.5 to obtain a corrected number of cycles. To make sure that gimbaling limitations are not exceeded, the cumulative total percentages of design life expended must not exceed 100 percent. An example of calculations to determine design life expended for gimbal bearing (under typical conditions) follows:

a. Series of gimbal cycles executed:

(1) Two cycles at 0.6 degrees

(2) Eight square-pattern cycles at 6.0 degrees

(3) Four cycles at 9.4 degrees

b. Percent of design life expended per cycle (figure 2-17):

(1) At 0.6 degrees, 0.0117 percent

(2) At 6.0 degrees, 0.102 percent

(3) At 9.4 degrees, 0.28 percent

c. Percent of design life expended for total cycles at each particular angular excursion (ie, percentages to be entered in Engine Log Book):

(1) At 0.6 degrees: 2 x 0.0117 = 0.0234 percent

(2) At 6.0 degrees (square pattern): corrected number of cycles = 1.5 x 8 = 12, and 12 x 0.102 = 1.224 percent

(3) At 9.4 degrees: 4 x 0.28 = 1.12 percent

d. Total cumulative percentages of design life expended for this series of gimbal cycles of gimbal cycles is 2.3674 percent (not entered in the Engine Log Book).

2.5.9.1 Gimbal Limit Constraints. Engine displacement, from the engine alined or null gimbal position, is limited to ±7.5 degrees through each actuator plane about the gimbal bearing. Engine displacement in a square pattern is limited to 10.6 degrees maximum.

2.5.10 ENGINE CHECKOUT CONSTRAINTS.

a. Protect engine openings, ports, fittings, and lines, to prevent the entry of foreign material.

b. For uninstalled engine checkout, install oxidizer and fuel inlet duct supports, fluid customer connect lines support, and customer connect electrical harness support.

c. Use suitable test lines or equipment connected to engine systems for service in the applicable system.

d. Perform tests at ambient temperature unless otherwise specified.

e. Verify acceptable leakage criteria, when leak-testing a flange connection provided with a leak detection port, using Pneumatic Flow Tester G3104 or leakage detection device with sensitivity equivalent to or better than the G3104. For seal rejection criteria, verify leakage using Pneumatic Flow Tester G3104 as specified in step h.

f. When leak-testing a flange connection provided with a leak detection port, apply the flowmeter to the port for a minimum of 10 seconds.

g. Convert Pneumatic Flow Tester G3104 measurements to scim using standard of 70° F and 29.92 inches of mercury.

square-pattern gimbaling, the number of square-pattern cycles must be multiplied first by 1.5 to obtain a corrected number of cycles. To make sure that gimbaling limitations are not exceeded, the cumulative total percentages of design life expended must not exceed 100 percent. An example of calculations to determine design life expended for gimbal bearing (under typical conditions) follows:

a. Series of gimbal cycles executed:

(1) Two cycles at 0.6 degrees

(2) Eight square-pattern cycles at 6.0 degrees

(3) Four cycles at 9.4 degrees

b. Percent of design life expended per cycle (figure 2-17):

(1) At 0.6 degrees, 0.0117 percent

(2) At 6.0 degrees, 0.102 percent

(3) At 9.4 degrees, 0.28 percent

c. Percent of design life expended for total cycles at each particular angular excursion (ie, percentages to be entered in Engine Log Book):

(1) At 0.6 degrees: 2 x 0.0117 = 0.0234 percent

(2) At 6.0 degrees (square pattern): corrected number of cycles = 1.5 x 8 = 12, and 12 x 0.102 = 1.224 percent

(3) At 9.4 degrees: 4 x 0.28 = 1.12 percent

d. Total cumulative percentages of design life expended for this series of gimbal cycles of gimbal cycles is 2.3674 percent (not entered in the Engine Log Book).

2.5.9.1 Gimbal Limit Constraints. Engine displacement, from the engine alined or null gimbal position, is limited to ±7.5 degrees through each actuator plane about the gimbal bearing. Engine displacement in a square pattern is limited to 10.6 degrees maximum.

2.5.10 ENGINE CHECKOUT CONSTRAINTS.

a. Protect engine openings, ports, fittings, and lines, to prevent the entry of foreign material.

b. For uninstalled engine checkout, install oxidizer and fuel inlet duct supports, fluid customer connect lines support, and customer connect electrical harness support.

c. Use suitable test lines or equipment connected to engine systems for service in the applicable system.

d. Perform tests at ambient temperature unless otherwise specified.

e. Verify acceptable leakage criteria, when leak-testing a flange connection provided with a leak detection port, using Pneumatic Flow Tester G3104 or leakage detection device with sensitivity equivalent to or better than the G3104. For seal rejection criteria, verify leakage using Pneumatic Flow Tester G3104 as specified in step h.

f. When leak-testing a flange connection provided with a leak detection port, apply the flowmeter to the port for a minimum of 10 seconds.

g. Convert Pneumatic Flow Tester G3104 measurements to scim using standard of 70° F and 29.92 inches of mercury.

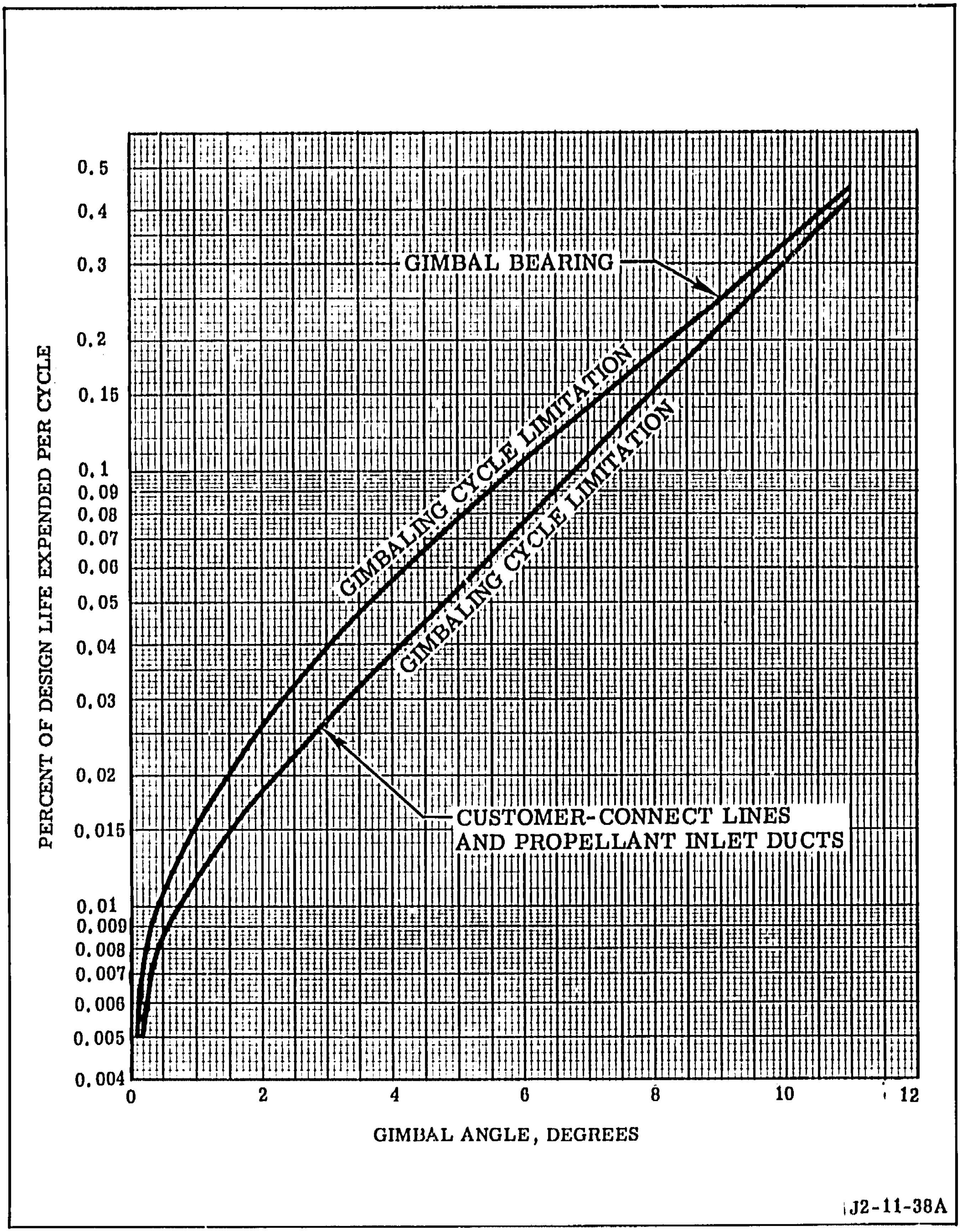


Figure 2-17. Gimbaling Limitations

h. When no leakage is specified for a flowmeter reading, use smallest tube of pneumatic flowtester. The ball in the smallest tube of Pneumatic Flow Tester G3104 may move off the stop momentarily but must not remain above the stop. Leakage that is not sufficient to hold the ball above the stop is acceptable.

i. When using leak-test compound, the criterion described as "Leakage is not allowable" is satisfied when no bubbles form within one minute.

WARNING

The following procedure specifies trichloroethylene or trichloroethane, which are toxic solvents. Inhalation of their vapors or prolonged contact with the liquids can cause serious injury or death.

- The following procedure specifies cleaning compound (MIL-C-81302), which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

j. Before pressurizing the system to be tested, remove tape and protective film from in-place-tube weld joints. Use care when removing tape and protective film, to prevent scratching the tubing. Immediately after removing tape, clean affected area with clean nylon cloth dampened with trichloroethylene (MIL-T-27602), trichloroethane (Federal Specification O-T-620), or cleaning compound (MIL-C-81302).

NOTE

Until successfully leak tested, a welded joint is considered an open port and, therefore, requires contamination protection.

- An in-place-tube weld joint that has not been leak tested may be rewelded to obtain a leak-free weld joint.

k. Leak-test in-place tube welds with leak-test compound (MSFC-SPEC-384) by applying compound and checking for bubble formation.

l. When leak-testing flight instrumentation pressure transducers, apply leak-test compound to transducer flange weld connection to pressure-sensing line. "Leakage is not allowable."

m. Do not apply leak-test compound to helium regulator assembly. Any bubbles that may form as a result of inadvertently applying leak-test compound on the helium regulator assembly should be disregarded, since the integrity of the seals is checked during the engine helium supply system pressure-decay test and helium usage test.

n. Remove leak-test compound with a clean, dry cloth after testing.

o. When specified in section I to leak test braided flex sections of lines, use a helium leak detector (Uson Model 500, Uson Corp, or A7-119, North American Rockwell Corp, or equivalent). Check braided flex sections covered with insulation by passing the detector probe across each joint of insulation to the line.

p. When leak-testing valve-to-start tank joints, do not use leak-test compound, since a false indication of leakage may be obtained. Gas emanating from under the start tank insulation cover may be caused from compression of entrapped air between tank and insulation and not from a defective tank.

q. If a system is disturbed or opened after completion of an authorized leak test, repeat the leak test on the disturbed or opened joint.

r. Leakage at engine checkout test plate connections is allowable if no audible leakage is detected.

s. Determine internal system leakage or component seal leakages with a flowmeter or by the pressure-decay method.

h. When no leakage is specified for a flowmeter reading, use smallest tube of pneumatic flowtester. The ball in the smallest tube of Pneumatic Flow Tester G3104 may move off the stop momentarily but must not remain above the stop. Leakage that is not sufficient to hold the ball above the stop is acceptable.

i. When using leak-test compound, the criterion described as "Leakage is not allowable" is satisfied when no bubbles form within one minute.

WARNING

The following procedure specifies trichloroethylene or trichloroethane, which are toxic solvents. Inhalation of their vapors or prolonged contact with the liquids can cause serious injury or death.

- The following procedure specifies cleaning compound (MIL-C-81302), which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

j. Before pressurizing the system to be tested, remove tape and protective film from in-place-tube weld joints. Use care when removing tape and protective film, to prevent scratching the tubing. Immediately after removing tape, clean affected area with clean nylon cloth dampened with trichloroethylene (MIL-T-27602), trichloroethane (Federal Specification O-T-620), or cleaning compound (MIL-C-81302).

NOTE

Until successfully leak tested, a welded joint is considered an open port and, therefore, requires contamination protection.

- An in-place-tube weld joint that has not been leak tested may be rewelded to obtain a leak-free weld joint.

k. Leak-test in-place tube welds with leak-test compound (MIL-L-25567) by applying compound and checking for bubble formation.

l. When leak-testing flight instrumentation pressure transducers, apply leak-test compound to transducer flange weld connection to pressure-sensing line. "Leakage is not allowable."

m. Do not apply leak-test compound to helium regulator assembly. Any bubbles that may form as a result of inadvertently applying leak-test compound on the helium regulator assembly should be disregarded, since the integrity of the seals is checked during the engine helium supply system pressure-decay test and helium usage test.

n. Remove leak-test compound with a clean, dry cloth after testing.

o. When specified in section I to leak test braided flex sections of lines, use a helium leak detector (Uson Model 500, Uson Corp, or A7-119, North American Rockwell Corp, or equivalent). Check braided flex sections covered with insulation by passing the detector probe across each joint of insulation to the line.

p. When leak-testing valve-to-start tank joints, do not use leak-test compound, since a false indication of leakage may be obtained. Gas emanating from under the start tank insulation cover may be caused from compression of entrapped air between tank and insulation and not from a defective tank.

q. If a system is disturbed or opened after completion of an authorized leak test, repeat the leak test on the disturbed or opened joint.

r. Leakage at engine checkout test plate connections is allowable if no audible leakage is detected.

s. Determine internal system leakage or component seal leakages with a flowmeter or by the pressure-decay method.

t. Remove protective closures as required to install test equipment. Closures and covers that do not have to be removed to install test equipment are removed in the applicable test procedure.

u. Retain attaching hardware of protective closures for reinstallation.

CAUTION

Distortion of engine lines can result in unsatisfactory engine operation.

v. When test procedures specify disconnection of engine hard lines, use extreme care to prevent line distortion. Miscellaneous attaching hardware may be loosened or removed, as necessary, to obtain clearance required to install and remove test plates if attaching hardware is reinstalled to the original configuration.

CAUTION

The reliability and durability of the engine can be adversely affected by rough treatment, such as stepping on or supporting weight on engine lines or components.

w. Do not apply unnecessary loads to engine lines or components.

x. When performing engine leak tests, if electrical power cannot be supplied through the interface, remote solenoid control box 99-0019901 may be used to energize the engine control valves.

y. When performing tests that require the engine to be in the components test mode, observe the following precautions to prevent burnout of the solenoid driver transistor biasing resistors in the ECA and to prevent inadvertent energization of the ignition-phase control solenoid when actuating the mainstage control solenoid:

(1) To prevent burnout of the solenoid driver transistor biasing resistors, electrical power for energizing the STDV control solenoid (P54, pin g), ignition-phase control solenoid (P54, pin R) and mainstage control solenoid (P54, pin f) must be supplied from engine electrical connector P54, pin Y.

(2) To prevent inadvertent energization of the ignition-phase control solenoid when actuating the mainstage control solenoid, electrical power must be applied to electrical connector P54, pin y (component test lockout command) or electrical connector P51, pin j (engine cutoff command).

2.5.10.1 <u>Engine Checkout Requirements After Storage.</u> When an engine is removed from storage after being stored in accordance with MSFC-STD-496 or MSFC-STD-498, checkout of the engine is required. Refer to section I for post-storage requirements.

2.5.11 <u>THRUST CHAMBER EXIT IGNITER REQUIREMENTS FOR STATIC TEST.</u> A gaseous hydrogen burner or a pyrotechnic igniter system must be used to prevent the accumulation of hydrogen around the engine between the engine start signal and the initiation of combustion in the thrust chamber.

2.5.11.1 <u>Gaseous Hydrogen Burner Exit Igniter Requirements.</u> The igniter must be located approximately 6 inches below the 30-35 inches to the side of the thrust chamber diffuser exit and mounted downward at an angle of 30-40 degrees. The igniter gaseous hydrogen feed system must deliver gaseous hydrogen at a flowrate between 0.001 and 0.0015 pound per second. The igniter must not be turned on before 10 seconds of engine start and must be turned off after engine main propellant ignition. If a spark igniter system is used as the combustion initiator for the igniter, the spark igniter must be turned off at engine start signal to prevent possible interference with the instrumentation system.

2.5.11.2 Pyrotechnic Exit Ignitor Requirements. If pyrotechnic igniters are to be used to prevent excess accumulation of hydrogen around the engine, pyrotechnic igniters 650580, or equivalent, are recommended. These igniters have a heat-release rate of 50-65 Btu per second and a burn duration of 3-6 seconds. For single-engine static tests, two igniters must be mounted diametrically opposite, approximately 6 inches below and 6-18 inches to the side of the thrust chamber diffuser exit. The radial firing planes must be parallel with the diffuser exit plane. For clustered-engine static tests, an ample number of igniters must be mounted to provide similar coverage of the exit plane; the igniters need not, however, be mounted diametrically opposite. Protect wiring against the exhaust flame heat flux and make sure there is ample clearance for engine gimbaling. The exit igniters must be fired at engine start signal.

2.5.12 FILM-COOLED DIFFUSER REQUIREMENTS. The engine must be equipped with a film-cooled diffuser for static testing at sea-level conditions. The coolant and purge supply requirements are as follows:

a. Coolant: water supplied to diffuser at a minimum flowrate of 20 lb/sec through diffuser. During engine operation, the water pressure must remain above 20 psig.

b. Coolant cleanness: water supplied from a system equipped with a 200-micron nominal, 250-micron absolute filter.

c. Purge media: gaseous nitrogen conforming to requirements of paragraph 2.1.2.3.

d. Purge sequence: The purge must be sequenced as outlined in figures 2-1, 2-2, and 2-3.

2.5.13 ENGINE SIDE-LOAD RESTRAINING ARM SYSTEM OPERATING REQUIREMENTS. The restraining arm system must meet the following requirements during engine static test: Restrainer and stiff arms must not be used concurrently under any circumstances. The gimbal actuator force, or equivalent, must be limited to 5,000 pounds maximum during engine start. (As an alternate criterion, the actuator must not cause a side load in excess of 1,000 pounds at the side load restrainer outrigger attach point during side load conditions of engine operation.)

2.5.14 ENGINE RESTART REQUIREMENTS. The following are additional established requirements to provide satisfactory start and operation of the engine on the second start in flight or to demonstrate restart in a static test series.

a. For static test, the helium tank pressure must be a minimum of 1,950 psia.

b. During static testing, first firing must be a minimum of 60 seconds duration to provide correct refilling and pressurization of start tank. On engines not incorporating MD366 or MD371 change, for flight applications, a minimum of 50 seconds of first 100 seconds of first-burn duration must be made with PU valve between null position and maximum mixture ratio position (valve fully closed).

bA. On engines incorporating MD366 or MD371 change, for flight applications, a minimum of 50 seconds of the first 100 seconds of first-burn duration must be conducted with the MRCV in the high EMR position.

c. Hold time between static tests must be a minimum of 45 minutes.

d. Hold time before in-flight restart must be a minimum of 80 minutes on engines incorporating MD260 and MD361 changes or 2 hours (minimum) on engines not incorporating MD260 and MD361 changes, and a maximum of 6 hours.

e. On engines not incorporating MD366 or MD371 change, for engine restart at an elapsed time of 80 minutes from initial cutoff, engine PU valve must be held in null position during initial 60 seconds at first engine burn and between null and minimum mixture ratio position (valve open) during remainder of first burn.

eA. On engines incorporating MD366 change, for engine restart at an elapsed time of 80 minutes from initial cutoff, the MRCV must be held in high EMR position during first 60 seconds of first engine burn and in either the low EMR position or high EMR position during the remainder of first burn.

f. On engines not incorporating MD366 change, engine PU valve must be held in minimum mixture ratio position (valve open) until at least 5 seconds after STDV open control signal for in-flight restart.

g. On engines incorporating MD366 change, the MRCV must be held in the low EMR position (valve open) until at least 5 seconds after STDV open control signal for in-flight restart.

2.5.15 HELIUM REGULATOR OPERATION CONSTRAINTS.

a. When engine helium regulator is operated, all actuations and deactuations of helium regulator and pressure level of each operation must be recorded in Engine Log Book, Helium Regulator Assembly Operation Record. Operation of the helium regulator means actuating and deactuating the regulator by energizing and deenergizing the helium control valve while the helium tank is pressurized.

b. When the engine helium regulator is operated with a helium tank pressure of 550 psig or greater and the helium regulator outlet pressure (NN2) is monitored, the monitored outlet pressure must be 400 ±25 psig.

c. On engines not incorporating MD333 change, the following requirements must be observed for operation of the engine regulator during engine checkout and operation:

(1) Pressure in the engine helium tank must be less than 100 psig or greater than 1,400 psig when the helium control valve is energized and less than 100 psig when the helium control valve is deenergized. During the sequence test, however, operation is automatic. (During preparation for launch, with over 3,000 psig in helium tank, control safe pressure in tank by actuating helium control valve to vent tank.)

(2) Vent pressure from helium tanks as follows:

(a) If pressure is greater than 1,400 psig or less than 100 psig, energize helium control valve.

(b) If pressure is between 100 and 1,400 psig and pressure cannot be increased, energize helium tank emergency vent control valve. If helium control valve is already energized, shut off helium supply pressure; then engine pneumatic system will bleed.

(3) After prelaunch helium supply system pressure decay test, vent engine helium tank only by energizing helium control valve. Helium tank pressure must be greater than 1,400 psig before energizing the helium control valve.

(4) To obtain regulator outlet pressure of less than 400 psig, energize helium control valve with tank pressure below 100 psig; then increase tank supply pressure to desired value.

2.5.15A. START TANK PRESSURE CYCLE LIFE. The following procedure determines the current engine start tank minimum pressure cycle life based on fracture mechanics analysis. This procedure includes general criteria for evaluating the flaw growth and cycle life, specific data related to the individual tank manufacture for use in flaw size and cycle life calculations, and an Engine Log Book work sheet for documenting the pressure cycle life and flaw growth calculation. A sample evaluation is included to demonstrate the use of the procedure.

2.5.15A.1 GENERAL CRITERIA. A pressure cycle is defined by using several criteria. Figure 2-18 shows sample histories of simple and complex pressure cycles. The simple history involves an initial monotonic pressure change from ambient pressure (P_{min}) to a maximum pressure (P_{max}), followed by a monotonic pressure change to P_{min}. (The increase or decrease in pressure can either be smooth or in steps.) Such a pressure cycle would constitute one cycle from P_{min} to P_{max}.

The complex history also has an initial pressure increase (P_{min}) and a final pressure decrease (P_{max}). However, the complex history involves intermediate cycling. To resolve the complex history into a series of cycles, observe the following rules:

a. Consider only the pressure increase in evaluating a cycle.

b. Include the major pressure cycle as one cycle from P_{min} to P_{max}.

c. Do not consider intermediate cycles with a P_{min} to P_{max} range less than 150 psig.

d. Do not consider major pressure cycles with P_{max} less than 700 psig.

e. Define intermediate cycles from their local P_{min} to P_{max} range, such as:

1 cycle of $P_{min_1} - P_{max_1}$

1 cycle of $P_{min_2} - P_{max_2}$

f. Base the P_{max_1} and P_{max_2} values on the adjacent plateau preceding the minimum pressure. The plateau following the P_{min_1} and P_{min_2} pressure is part of the primary $P_{min} - P_{max}$ cycle and must not be used for the local pressure range calculation. (See figure 2-18.)

g. Relate an intermediate cycle (P_{min} - P_{max}) to an equivalent 0 to P_{max} cycle by using figure 2-18A, which relates the ratio (R) to an equivalent cycle (S). (R is defined as the ratio of P_{min} to P_{max}. Therefore, a cycle of P_{min_1} to P_{max_1} is related through the R ratio and figure 2-18A to an equivalent fractional cycle S_1 to a 0 to P_{max_1} pressurization.)

2.5.15A.2 The largest initial flaw after proof test occurs in the tank girth weld zone. The flaw size and cycle life calculations use the specific manufacturing information on each tank. The NAR Columbus tank has an 0.21 inch girth weld and the Airite tank has an 0.138 inch girth weld. (See figures 2-18B through 2-18E.)

2.5.15A.3 To evaluate the flaw growth per cycle, determine the equivalent 0 to P_{max} pressure cycle. Use the P_{max} pressure and the current maximum flaw size recorded on the work sheet (figure 2-18F) with figure 2-18B or figure 2-18D to obtain the flaw growth rate per cycle (da/dN). The flaw growth (Δa) for this cycle is then the equivalent cycle (S) times da/dN. A series of cycles (N) at the same value can be combined into an equivalent flaw growth (Δa) if their total increment of flaw growth (Δa) is less than 200 microinches ($\Delta a = N \times S \times da/dN < 200$). For combinations greater than 200 microinches, divide into groups of less than 200 microinches (approximately in half if possible). The current flaw size is the accumulation of the initial flaw and the flaw growth for each cycle. The cycle life remaining at any specific flaw size for a specific 0 to P_{max} cycle is determined from figure 2-18C or figure 2-18E.

2.5.15A.4 FLAW GROWTH CALCULATION EXAMPLE. In this example flaw growth calculation for a typical engine, the pressure cycle history of the engine includes 10 cycles of various pressures, which are listed in column 2 of figure 2-18F (Sample J-2 Start Tank Pressure Cycle Life Work Sheet). The proof pressure for this tank was 1,850 psig and resulted in an initial flaw size of 0.1606 inch or 160,600 microinches (figure 2-18B), which is recorded in column 7 of the work sheet. Using figure 2-18C, the remaining cycle life of 0 to 1,400 psig pressure cycles at the current flaw size of 160,600 microinches was determined to be 33 cycles.

The flaw growth for each subsequent pressurization cycle is obtained next by referring to figure 2-18B and using the P_{max} pressure (1,240 psig for the first cycle) and the current flaw size (160,600 microinches for the first cycle). For pressurizations of 0 to P_{max} (0 to 1,240 psig for the first cycle) the flaw growth is equal to the flaw growth per cycle since R = 0 and S = 1. The current flaw size is obtained by adding the increment of flaw growth (Δa) to the previous flaw size. For the first cycle this is

Initial size	160,600	microinches (obtained from column 7 of work sheet)
Δa	+000,162	microinches (obtained from figure 2-18B)
Current flaw size	160,762	microinches (recorded in column 7 of work sheet)

Each pressurization cycle is handled the same way until the cycle at 550-1,100 psig is reached. In this case, an R factor and equivalent fractional cycle (S) of 0-1,100 psig pressurization are obtained.

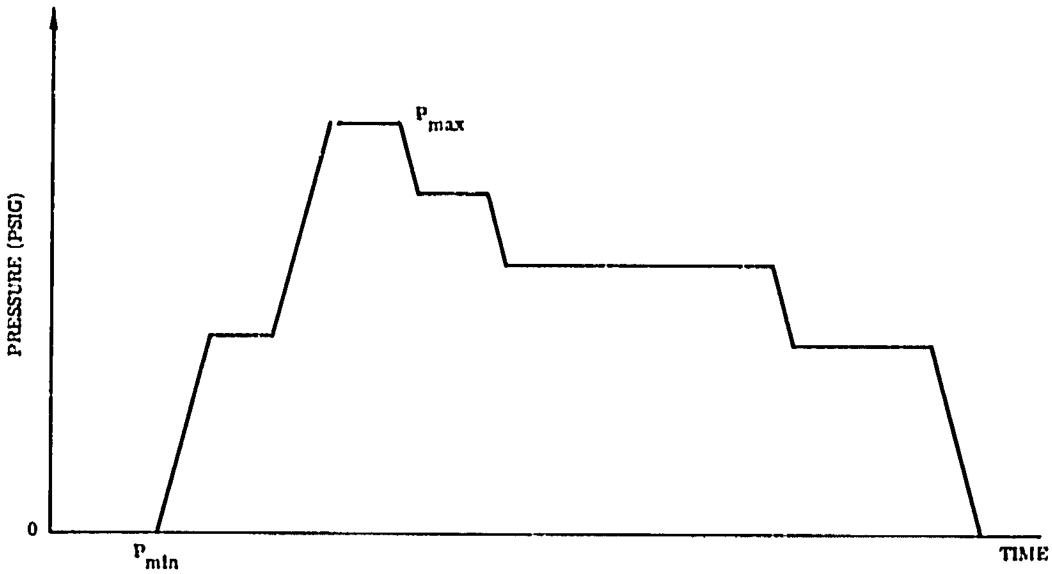
$$R = \frac{P_{min}}{P_{max}} = \frac{550}{1{,}100} = 0.500$$

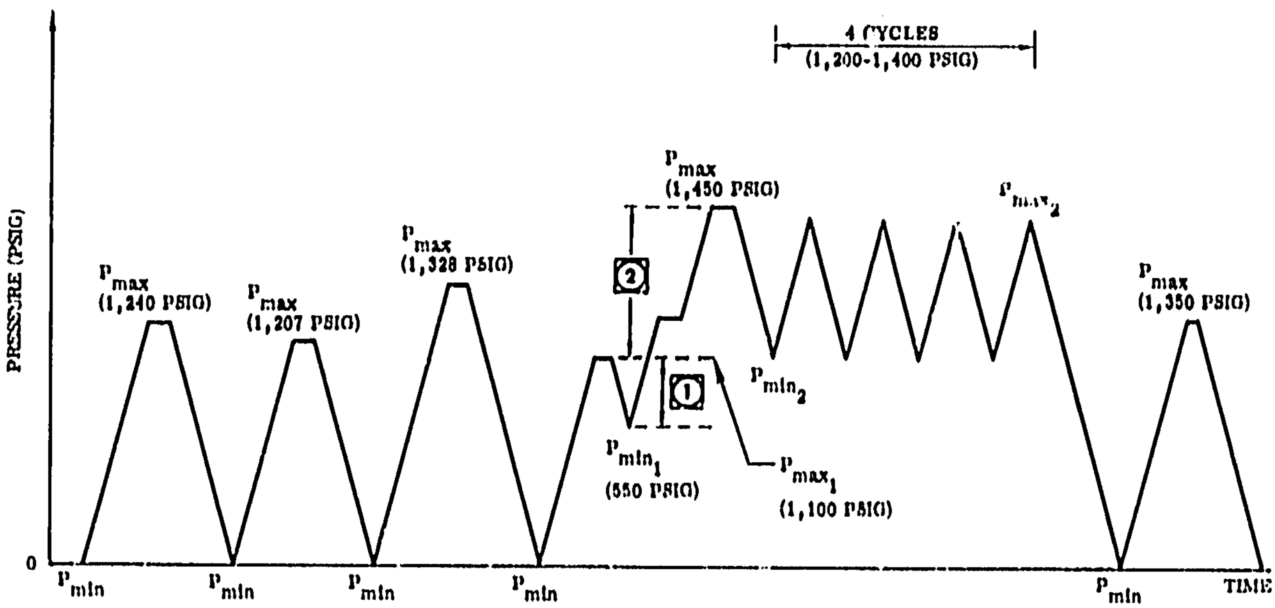
This value is recorded in column 3 of work sheet. The equivalent cycle (S) is then determined from figure 2-18A to be 0.415. This value is recorded in column 4 of work sheet. Using the last recorded value in column 7 (161,177) and figure 2-18B, the additional flaw growth for a 0-1,100 psig cycle is determined to be 75 microinches. This value is recorded

in column 5 of work sheet. Next, the increment of flaw growth is determined by multiplying values in columns 1, 4, and 5 (1 x 0.415 x 75 = 31 microinches) of work sheet. This value (31) is recorded in column 6. The current flaw size is then obtained by adding the column 6 value (31) to the last record value in column 7 (161,177). This value (161,208) is recorded in column 7.

The 4 cycles at 1,200-1,400 psig are calculated the same way except they can be combined into one entry since their total combined increment of flaw growth is less than 200 microinch.

The cycle life for the tank can be obtained at the end of any pressurization. For example, after the last tabulated pressurization, the flaw size is 162,053 microinch or 0.1621 inch. From figure 2-18C it can be determined that the remaining cycle life of 0-1,400 psig pressurization is 20 cycles.





1 ONLY THIS PART OF THE PRESSURE INCREASE IS INCLUDED IN THE INTERMEDIATE CYCLE.

2 THIS PRESSURE INCREASE IS INCLUDED IN THE MAJOR CYCLE.

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Figure 2-18. Typical Pressure Cycle Histories

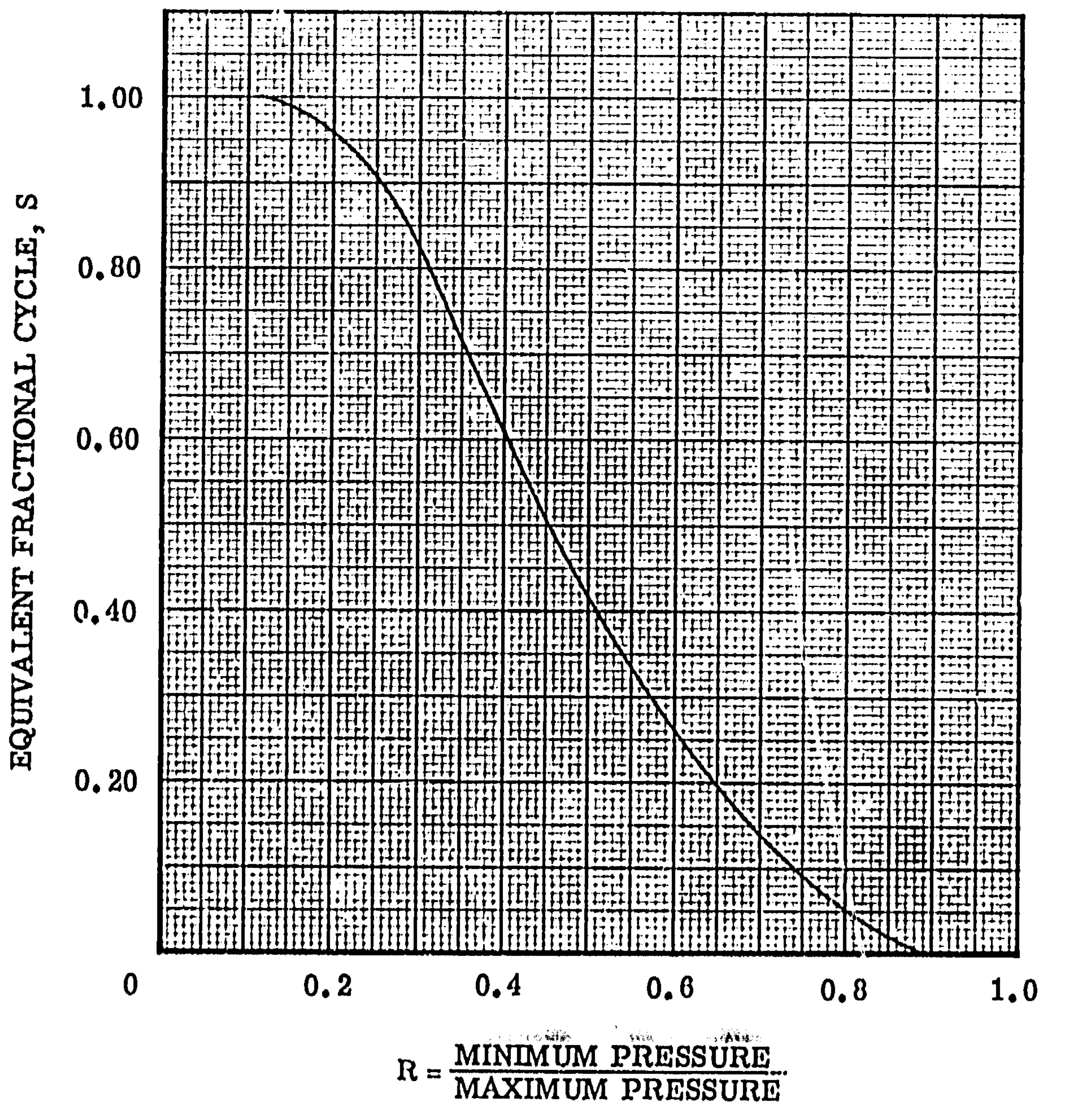

Figure 2-18A. Equivalent Fraction of 0 to P_{max} Cycle as Function of Pressure Ratio

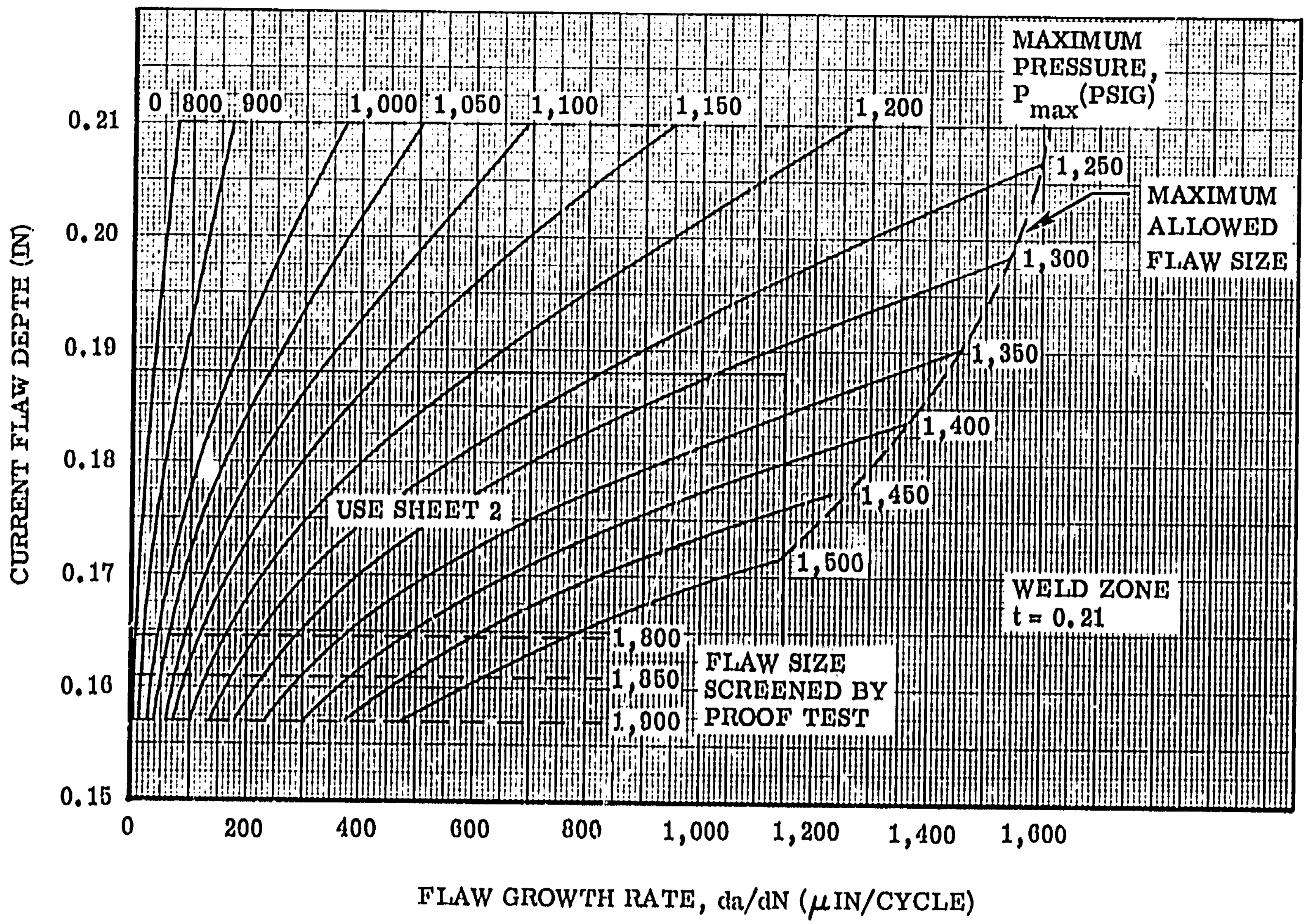

Figure 2-18B. Flaw Growth Rate at Specific Flaw Depth for Various 0 to P_{max} Pressure Cycles (NAR Columbus Tank) (Sheet 1 of 2)

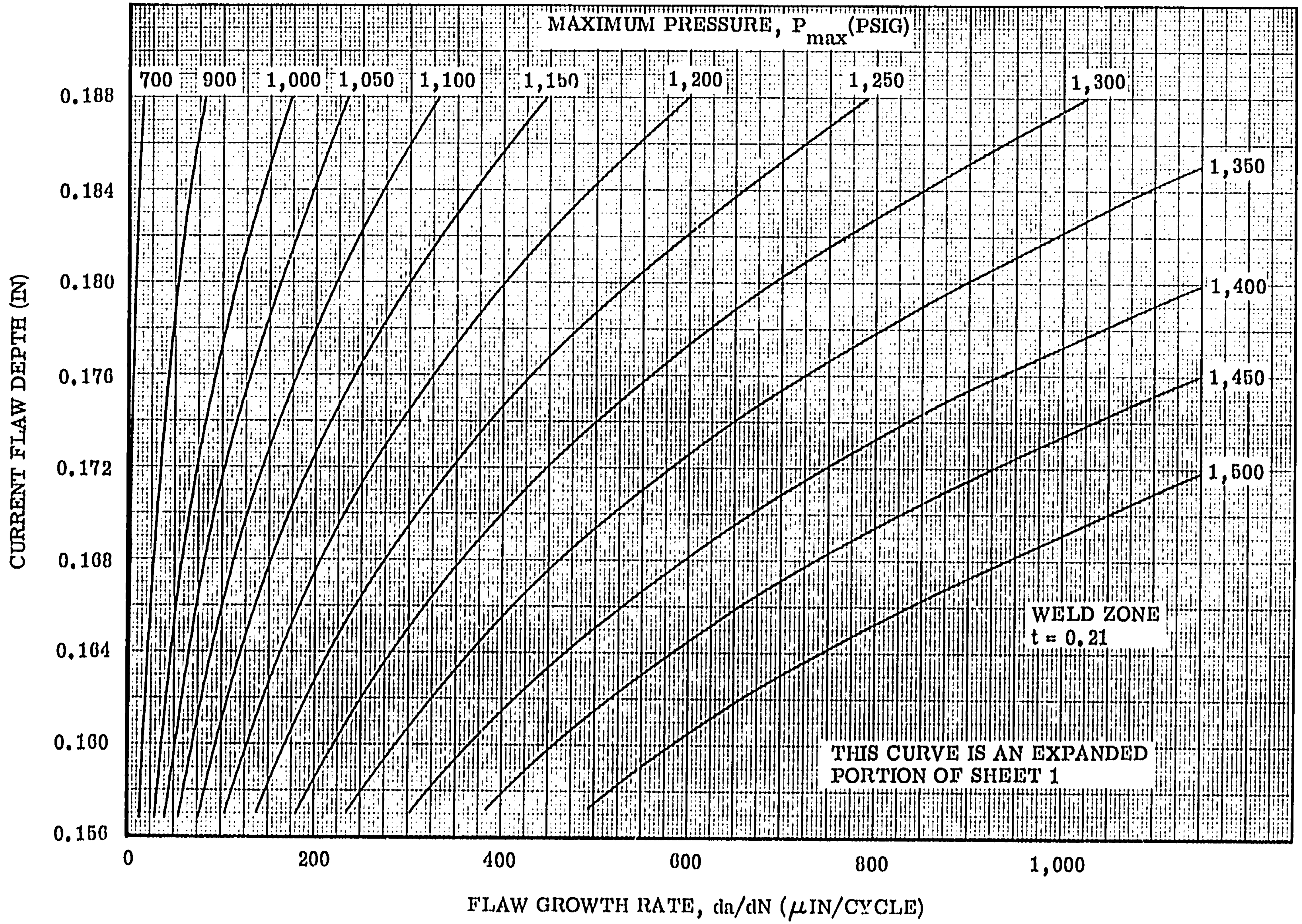

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Figure 2-18B. Flaw Growth Rate at Specific Flaw Depth for Various 0 to P_{max} Pressure Cycles (NAR Columbus Tank) (Sheet 2 of 2)

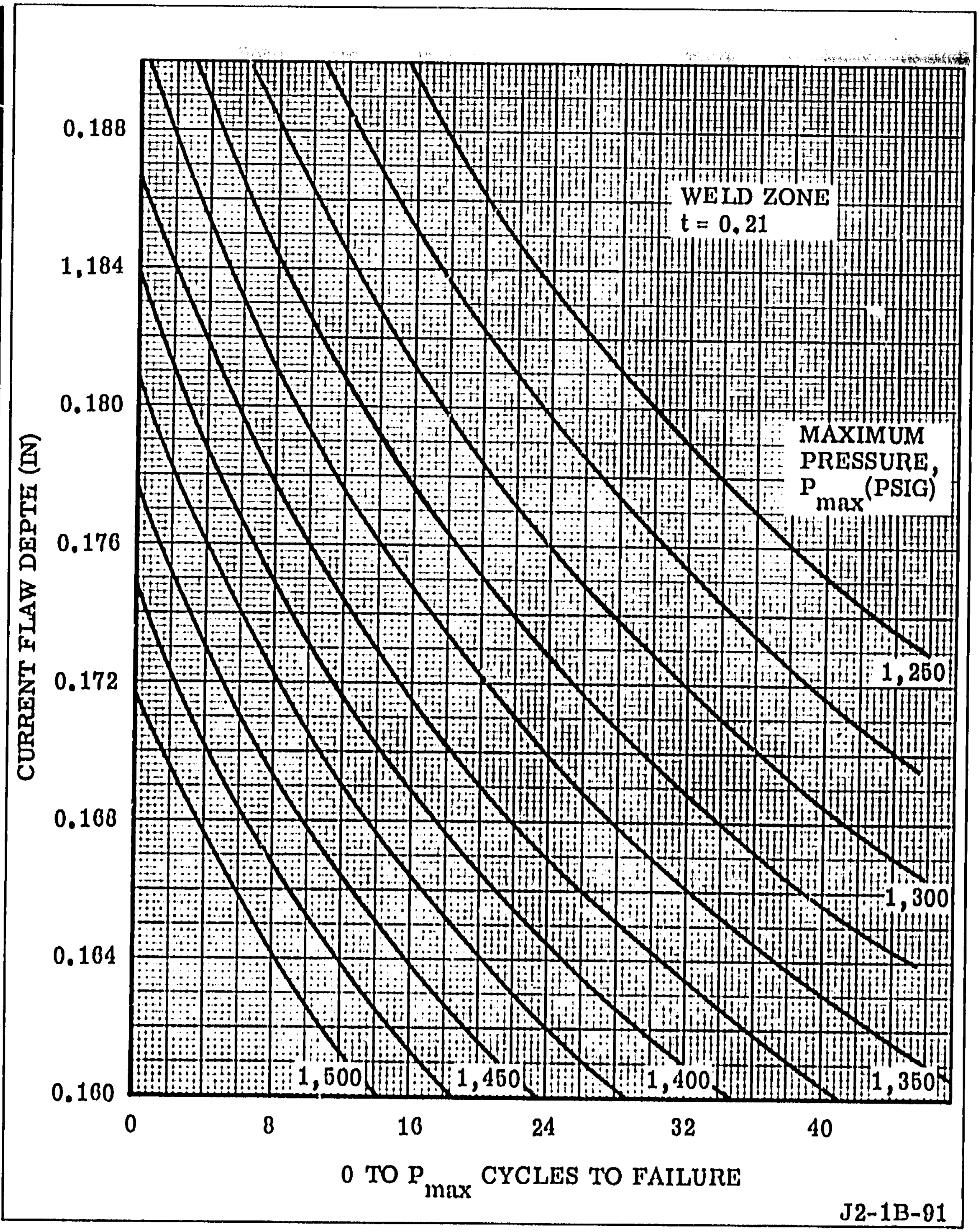

Figure 2-18C. Cycles to Failure at the Current Flaw Depth (NAR Columbus Tank)

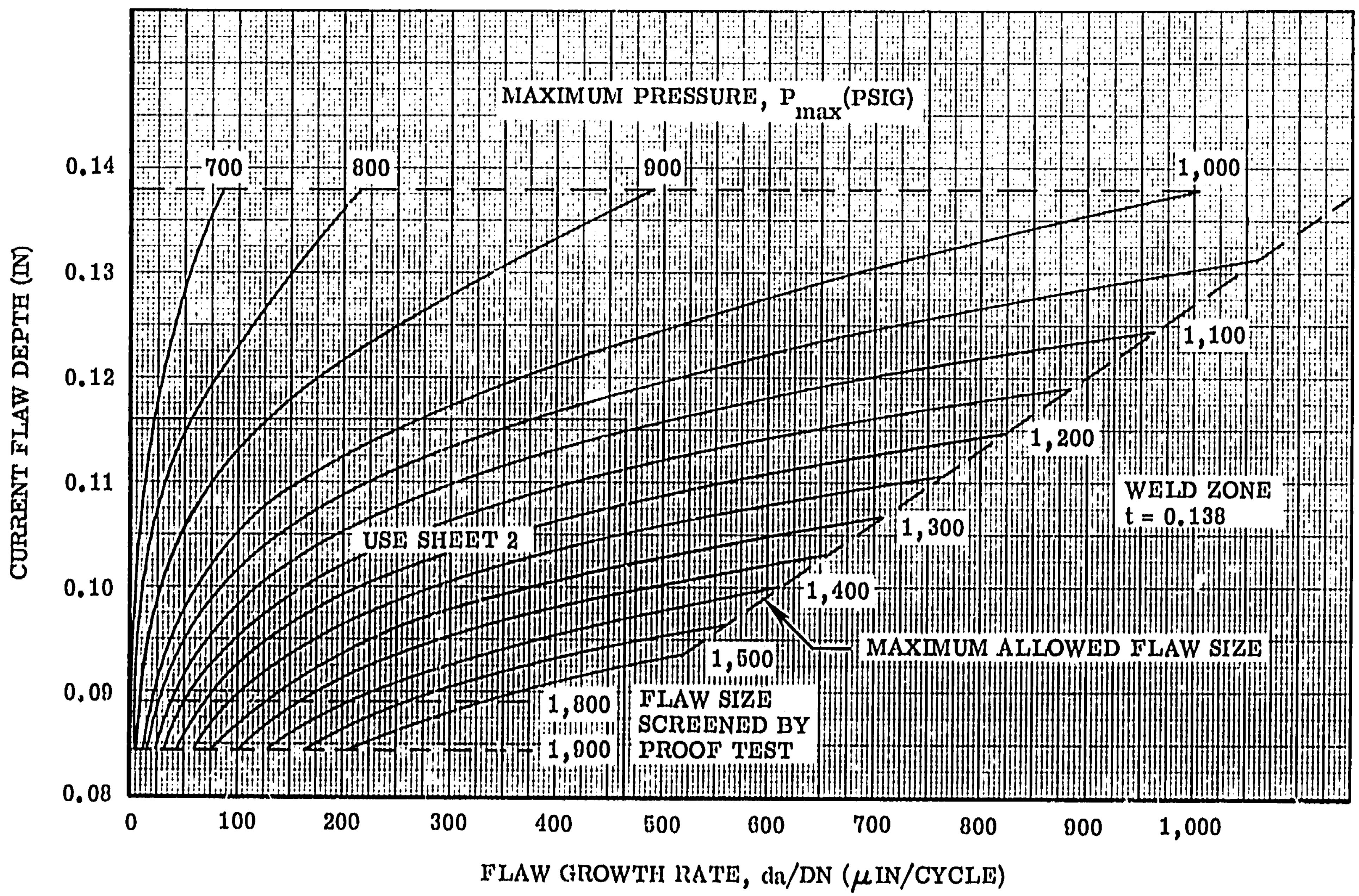

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Figure 2-18D. Flaw Growth Rate at Specific Flaw Depth for Various 0 to P_{max} Pressure Cycles (Airite Tank) (Sheet 1 of 2)

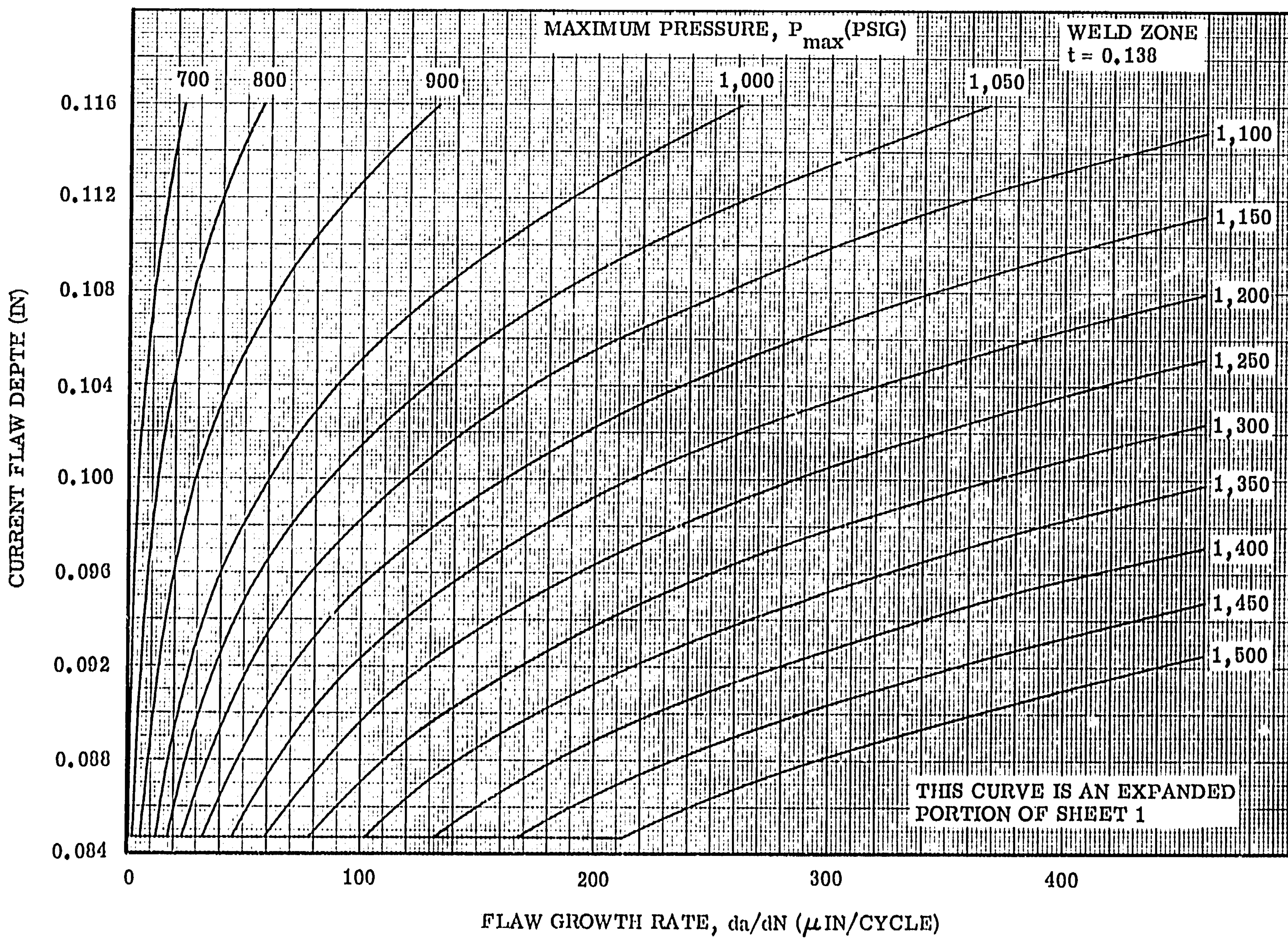


Figure 2-18D. Flaw Growth Rate at Specific Flaw Depth for Various 0 to P_{max} Pressure Cycles (Airite Tank) (Sheet 2 of 2)

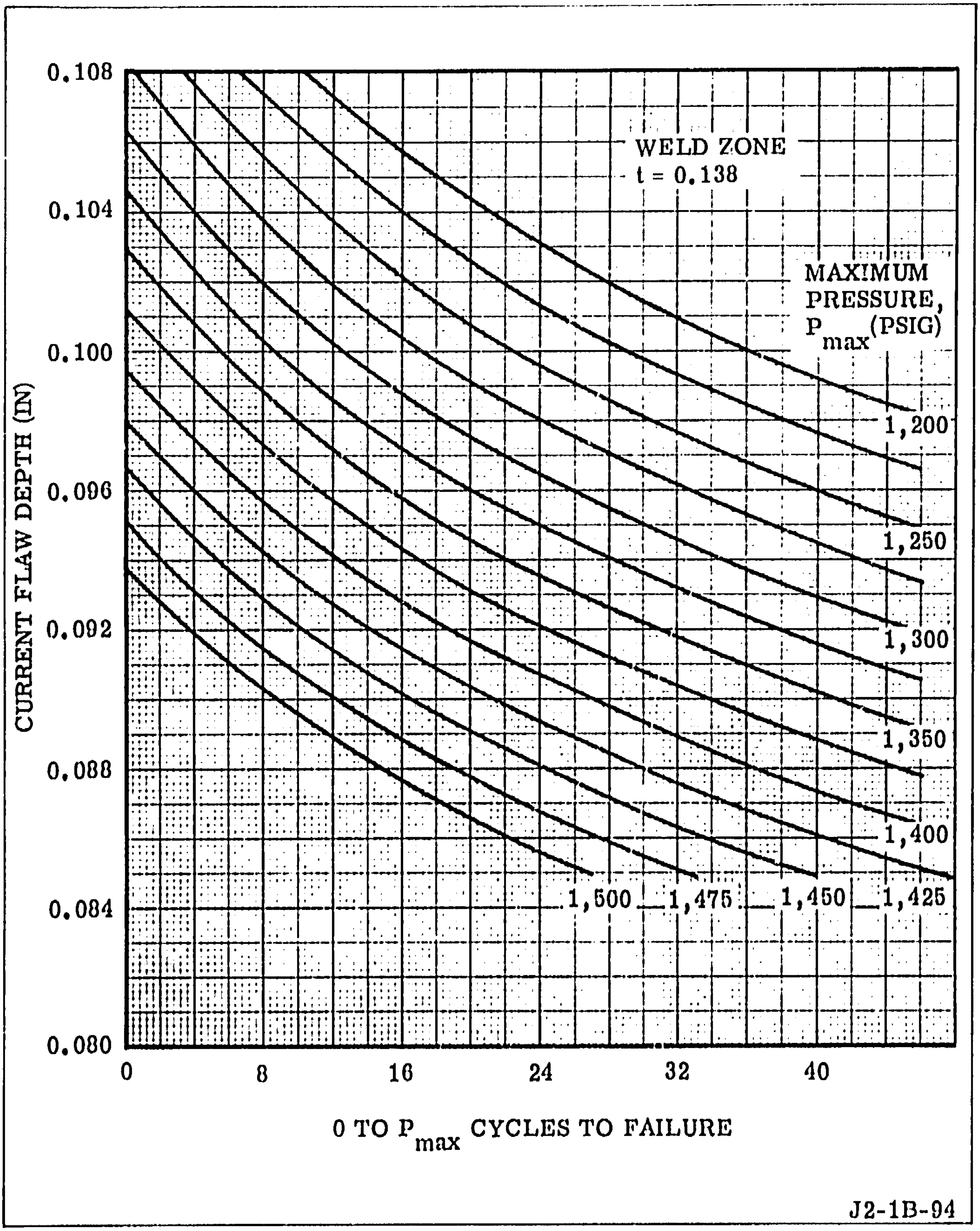


Figure 2-18E. Cycles to Failure at the Current Flaw Depth (Airite Tank)

ENGINE NO. J-XXXX VEHICLE SA-XXX POSITION XX P/N XXXX

S/N XXXXXX MFG. NAR-Columbus

1 NUMBER CYCLES AT SAME CONDITION N	2 PRESSURE CYCLE P_{MIN} TO P_{MAX} (PSIG) (PSIG)	3 R $\left(\frac{P_{MIN}}{P_{MAX}}\right)$	4 EQUIVALENT FRACTION OF 0 TO P_{MAX} CYCLE S	5 FLOW GROWTH RATE, da/dn, AT CURRENT FLAW SIZE AND P_{MAX} (μ IN)	6 INCREMENT OF FLAW GROWTH 1 x 4 x 5 (μ IN)	7 CURRENT MAXIMUM FLAW SIZE (μ IN)	8 CYCLE LIFE REMAINING (0-1400 PSIG)
	PROOF PRESSURE 1,850 PSIG					160,600	33
1	0-1,240	0	1	162	162	160,762	32
1	0-1,207	0	1	140	140	160,902	32
1	0-1,328	0	1	275	275	161,177	31
1	550-1,100	0.500	0.415	75	31	161,208	31
1	0-1,450	0	1	493	493	161,701	30
4	1,200-1,400	0.857	0.020	405	32	161,733	29
1	0-1,350	0	1	320	320	162,053	29

Figure 2-18F. Sample J-2 Start Tank Pressure Cycle Life Work Sheet (Typical)

2.5.16 (Deleted)

2.5.16A FLIGHT OPERATION CONSTRAINTS.

WARNING

Failure to adhere to the following constraints will result in fuel and oxidizer mixing, which could result in vehicle loss.

a. Apply engine cutoff power continuously when the mainstage control solenoid is energized, to prevent the ignition phase control solenoid from energizing when the mainstage control solenoid is actuated to dump oxidizer through the main oxidizer valve.

b. When opening the main fuel valve or main oxidizer valve for dumping propellants, do not operate mainstage and ignition phase control solenoids simultaneously or in such a time sequence as to cause fuel and oxidizer to mix. Engine cutoff power must be applied, to prevent the ignition-phase control solenoid from energizing when actuating the mainstage control solenoid.

2.5.17 STATIC-TEST INSTRUMENTATION REQUIREMENTS. If the instrumentation output is used for data reduction and/or engine performance verification during static testing, the instrument accuracy must meet the requirements of figure 2-19.

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Time Period/Action/Notes
PRIMARY FLIGHT INSTRUMENTATION				
CG1	Thrust chamber pressure	0-1,000 psia	±0.5	Thrust chamber pressure measurement is also provided by stage-static-test instrumentation taps CG1 and CG1a.
GG1[a]	GG chamber pressure	0-1,000 psia	±1.0	GG chamber pressure measurement is also provided by stage-static-test instrumentation tap GG1a.
NN1	Helium tank pressure	0-3,500 psia 0-5,000 psia[b]	±2.0	Helium tank pressure measurement is also provided to stage-static-test instrumentation and on engines incorporating MD269, MD282, MD296, MD313, MD314, or MD315 change to auxiliary flight instrumentation.
PF3	Fuel pump discharge pressure	0-1,500 psia	±2.0	Fuel pump discharge measurement is also provided by stage-static-test instrumentation tap PF2.
PO3	Oxidizer pump discharge pressure	0-2,000 psia[c] 0-1,500 psia	±2.0	On engines incorporating MD237 change, oxidizer pump discharge pressure measurement is also provided to stage-static-test instrumentation tap PO3.

(a) On engines not incorporating MD237 change.
(b) On engines incorporating MD282, MD313, or MD315 change.
(c) On engines incorporating MD172 change.

Figure 2-19. Static-Test Instrumentation Requirements (Sheet 1 of 12)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Time Period/Action/Notes
	PRIMARY FLIGHT INSTRUMENTATION (cont)			
TF1	Start tank pressure	0-1,500 psia 0-3,500(d) psia	±2.0	Start tank pressure measurement is also provided to stage-static-test instrumentation and on engines incorporating MD269, MD282, MD296, MD313, MD314, or MD315 change to auxiliary instrumentation.
TG1(e)	Fuel turbine inlet pressure	0-1,000 psia	±2.0	Fuel turbine inlet pressure measurement is also provided to stage-static-test instrumentation.
CFT2 CFT2a(f)	Main fuel injection temperature	-425° to -100° F	±2.0	On engines not incorporating MD262 change, main fuel injection temperature is also provided by instrumentation tap CFT2a.
CS1	Thrust chamber jacket No. 1 temperature	-350° to +100° F	±2.0	
CS1a	Thrust chamber jacket No. 2 temperature	-350° to +100° F	±2.0	Temperature measurement at thrust chamber jacket No. 2 instrumentation tap is required unless temperature measurement is made at thrust chamber jacket No. 1 instrumentation tap CS1.

(d) On engines incorporating MD282, MD296, MD313, MD314, or MD315 change.
(e) On engines incorporating MD237 change.
(f) On engines not incorporating MD262 change.

Figure 2-19. Static-Test Instrumentation Requirements (Sheet 2 of 12)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Time Period/Action/Notes
PRIMARY FLIGHT INSTRUMENTATION (cont)				
GFT1	Fuel bleed valve temperature	-425° to -375° F	±2.0	
GOT2	Oxidizer bleed valve temperature	-300° to -250° F	±2.0	Temperature measurement at either oxidizer bleed valve instrumentation tap GOT2 or oxidizer turbopump discharge instrumentation tap POT3 is required. On engines incorporating MD248 change, only one sensor of the dual-element transducer is used for oxidizer bleed valve temperature measurement.
NNT1	Helium tank temperature	-300° to +200° F	±2.0	
PFT1	Fuel turbopump discharge temperature	-425° to -400° F	±2.0	
POT3	Oxidizer pump discharge temperature	-300° to -250° F	±2.0	Temperature measurement at either oxidizer pump discharge instrumentation tap POT3 or oxidizer bleed valve instrumentation tap GOT2 is required.
TFT1	Start tank temperature	-350° to +100° F	±2.0	
TGT1	Fuel turbine inlet temperature	0° to 1,800° F	±2.0	On engines not incorporating MD237 change, fuel turbine inlet temperature measurement is also provided by stage-static-test instrumentation taps TG1a and TG1b.

Figure 2-19. Static-Test Instrumentation Requirements (Sheet 3 of 12)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Time Period/Action/Notes
	PRIMARY FLIGHT INSTRUMENTATION (cont)			
TGT3[(g)]	Oxidizer turbine inlet temperature	0° to 1,200° F	±2.0	
TGT4[(g)]	Oxidizer turbine exhaust temperature	0° to 1,000° F	±2.0	
--	ECA temperature	-300° to +200° F	±2.0	
--	Primary FI temperature	-300° to +200° F	±2.0	
PFV	Fuel pump speed	5,000-30,000 rpm	±2.0	Secondary (calibration) coil is used for stage measurement; electrical signal is at patch-panel.
POV	Oxidizer pump speed	1,000-12,000 rpm	±2.0	Secondary (calibration) coil is used for stage measurements; electrical signal is at patch-panel.
PFF	Main fuel flowrate	1,000-10,000 gpm	±2.0	Main fuel flowrate measurement is also provided by stage-static-test instrumentation tap PFFa.
POF	Main oxidizer flowrate	300-4,000 gpm	±2.0	Main oxidizer flowrate measurement is also provided by stage-static-test instrumentation tap POFa.
--	MFV position	0-100%		Stage test applies to potentiometer trace.
--	MOV position	0-100%		Stage test applies to potentiometer trace.
--	GG control valve position	0-100%		Stage test applies to potentiometer trace.
--	Fuel bleed valve position	On-off		

(g) On engines incorporating MD263 change, transducer port is plugged; on engines incorporating MD274 change, plug is replaced by a transducer.

Figure 2-10. Static-Test Instrumentation Requirements (Sheet 4 of 12)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range	Time Period/Action/Notes
	PRIMARY FLIGHT INSTRUMENTATION (cont)			
--	Oxidizer bleed valve position	On-off		
--	OTBV position	0-100%		Stage test applies to potentiometer trace.
--	ASI valve position	On-off		
--	PU valve position(l)	0-100%		
--	MRCV position(m)	Low EMR-high EMR		
--	STDV position	0-100%		
--	Ignition bus voltage	0-60 vdc		Measurement range 0-60 vdc; engine bus upper limit 32 vdc.
--	Control bus voltage	0-60 vdc		Measurement range 0-60 vdc; engine bus upper limit 32 vdc.
--	Engine ready electrical signal	On-off		
--	Helium control on electrical signal	On-off		
--	Ignition phase control on electrical signal	On-off		
--	ASI spark on electrical signal	On-off		
--	GG spark on electrical signal	On-off		
--	Mainstage control on electrical signal	On-off		
--	Start tank discharge control on electrical signal	On-off		

(l) On engines not incorporating MD366 or MD371 change.
(m) On engines incorporating MD366 or MD371 change.

Figure 2-19. Static-Test Instrumentation Requirements (Sheet 5 of 12)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Time Period/Action/Notes
	PRIMARY FLIGHT INSTRUMENTATION (cont)			
--	Ignition complete electrical signal	On-off		
--	Mainstage OK No. 1 pressurized electrical signal	On-off		
--	Mainstage OK No. 2 pressurized electrical signal	On-off		
--	Mainstage OK No. 1 depressurized electrical signal	On-off		
--	Mainstage OK No. 2 depressurized signal	On-off		
--	Engine cutoff vehicle electrical signal	On-off		
--	Engine cutoff lock-in electrical signal	On-off		
	AUXILIARY FLIGHT INSTRUMENTATION			
CF2	Main fuel injection pressure	0-1,500 psia	±2.0	On engines incorporating MD237 change, main fuel injection pressure measurement is also provided to stage-static-test instrumentation. On engines not incorporating MD237 change, main fuel injection pressure measurement is also provided by stage-static-test instrumentation tap CF2a.
CO3	Main oxidizer injection pressure	0-1,500 psia[b] 0-1,000 psia	±2.0	

(b) On engines incorporating MD282, MD313, or MD315 change.

Figure 2-19. Static-Test Instrumentation Requirements (Sheet 6 of 12)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Time Period/Action/Notes
	AUXILIARY FLIGHT INSTRUMENTATION (cont)			
GF4	GG fuel injection pressure	0-1,000 psia	±2.0	GG fuel injection pressure measurement is also provided to stage-static-test instrumentation.
GO5	GG oxidizer injection pressure	0-1,500 psia(c) 0-1,000 psia	±2.0	GG oxidizer injection pressure measurement is also provided to stage-static-test instrumentation.
HF2(h)(i)	Hydrogen tap-off outlet pressure		±2.0	
HO1(j)	Heat exchanger oxidizer inlet pressure	0-1,500 psia(c) 0-1,000 psia	±2.0	
NN1	Helium tank pressure	0-3,500 psia 0-5,000 psia(b)	±2.0	On engines incorporating MD269, MD282, MD296, MD313, MD314, or MD315 change, helium tank pressure measurement is also provided to stage-static-test and primary flight instrumentation.
NN2	Helium regulator outlet pressure	0-750 psia	±2.0	Helium outlet pressure measurement is also provided to stage-static-test instrumentation.
PF5	Fuel pump balance piston cavity pressure	0-1,000 psia	±2.0	Fuel pump balance piston cavity pressure measurement is also provided to stage-static-test instrumentation.

(b) On engines incorporating MD282, MD313, or MD315 change.
(c) On engines incorporating MD172 change.
(h) On engines not incorporating MD172 or MD206 change.
(i) On engines not incorporating MD269, MD282, MD296, MD313, MD314, or MD315 change.
(j) On engines not incorporating MD105 or MD194 change.

Figure 2-19. Static-Test Instrumentation Requirements (Sheet 7 of 12)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Time Period/Action/Notes
AUXILIARY FLIGHT INSTRUMENTATION (cont)				
PO6	Oxidizer turbopump primary seal pressure	0-50 psia	±2.0	Oxidizer turbopump primary seal pressure measurement is also provided to stage-static-test instrumentation.
PO8	PU valve inlet pressure	0-1,500 psia(c) 0-1,000 psia	±2.0	
PO9	PU valve outlet pressure	0-500 psia	±2.0	
TF1	Start tank pressure	0-1,500 psia 0-3,500(d) psia	±2.0	On engines incorporating MD269, MD282, MD313, MD314, or MD315 change, start tank pressure measurement is also provided to stage-static-test and primary flight instrumentation.
TG3	Oxidizer turbine inlet pressure	0-200 psia	±2.0	
TG4	Oxidizer turbine exhaust pressure	0-100 psia	±2.0	Oxidizer turbine exhaust pressure measurement is also provided to stage-static-test instrumentation.
HOT2(k)	Heat exchanger oxidizer outlet temperature	-200° to +500° F	±2.0	

(c) On engines incorporating MD172 change.
(d) On engines incorporating MD282, MD296, MD313, MD314, or MD315 change.
(k) On engines not incorporating MD100 change.

Figure 2-19. Static-Test Instrumentation Requirements (Sheet 8 of 12)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Time Period/Action/Notes
	AUXILIARY FLIGHT INSTRUMENTATION (cont)			
--	Auxiliary FI package temperature	-300° to +200° F	±2.0	
	STAGE-STATIC INSTRUMENTATION			
CF2[e] CF2a[a]	Main fuel injection pressure	0-1,500 psia[c] 0-1,000 psia	±2.0	Main fuel injection pressure measurement is also provided to auxiliary flight instrumentation by tap CF2.
CG1a	Thrust chamber pressure	0-1,000 psia	±0.5	Thrust chamber pressure measurement is also provided to primary flight instrumentation by tap CG1.
GF4	GG fuel injection pressure	0-1,000 psia	±2.0	GG fuel injection pressure measurement is also provided to auxiliary flight instrumentation.
GG1a[a]	GG chamber pressure	0-1,000 psia	±1.0	GG chamber pressure measurement is also provided by primary flight instrumentation tap GG1.
GO5	GG oxidizer injection pressure	0-1,500 psia	±2.0	GG oxidizer injection pressure measurement is also provided to auxiliary flight instrumentation.
TF1	Start tank pressure	0-1,500 psia 0-3,500 psia[d]	±2.0	Helium tank pressure measurement is also provided to primary flight instrumentation. On engines incorporating MD269, MD282, MD296, MD313, MD314, or MD315 change, helium tank pressure measurement is also provided to auxiliary flight instrumentation.

(a) On engines not incorporating MD237 change.
(c) On engines incorporating MD172 change.
(d) On engines incorporating MD282, MD296, MD313, MD314, or MD315 change.
(e) On engines incorporating MD237 change.

Figure 2-19. Static-Test Instrumentation Requirements (Sheet 9 of 12)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Time Period/Action/Notes
STAGE-STATIC INSTRUMENTATION (cont)				
NN1	Helium tank pressure	0-3,500 psia 0-5,000 psia[b]	±2.0	Helium tank pressure measurement is also provided to primary flight instrumentation. On engines incorporating MD269, MD282, MD296, MD313, MD314, or MD315 change, helium tank pressure measurement is also provided to auxiliary flight instrumentation.
NN2	Helium regulator outlet pressure	0-750 psia	±2.0	Helium regulator outlet pressure measurement is also provided to auxiliary flight instrumentation.
PF2	Fuel pump discharge pressure	0-1,500 psia	±2.0	Fuel pump discharge pressure measurement is also provided by primary flight instrumentation tap PF3.
PF5	Fuel pump balance piston cavity pressure	0-1,000 psia	±2.0	Fuel pump balance piston cavity measurement is also provided to auxiliary flight instrumentation.
PO2[a] PO3[c]	Oxidizer pump discharge pressure	0-2,000 psia	±2.0	On engines incorporating MD237 change, oxidizer pump discharge pressure measurement is also provided to primary flight instrumentation by tap PO3.
PO6	Oxidizer pump primary seal pressure	0-50 psia	±2.0	Oxidizer pump primary seal pressure measurement is also provided to auxiliary flight instrumentation.

(a) On engines not incorporating MD237 change.
(b) On engines incorporating MD282, MD313, or MD315 change.
(c) On engines incorporating MD237 change.

Figure 2-19. Static-Test Instrumentation Requirements (Sheet 10 of 12)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	(Error (Percent of Full Range)	Time Period/Action/Notes
STAGE-STATIC INSTRUMENTATION (cont)				
TGT1a(a) TGT1b(a)	Fuel turbine inlet temperature	0° to 1,800° F	±2.0	Fuel turbine inlet temperature is also provided by primary flight instrumentation tap TGT1.
TGT2	Fuel turbine exhaust temperature	0° to 1,800° F	±2.0	
--	ECA temperature	-300° to +200° F	±2.0	
PFFa	Main fuel flowrate	1,000-10,000 gpm	±2.0	Main fuel flowrate measurement is also provided by primary flight instrumentation tap PFF.
POFa	Main oxidizer flowrate	300-4,000 gpm	±2.0	Main oxidizer flowrate measurement is also provided by primary flight instrumentation tap POF.
ENGINE-MONITORED INSTRUMENTATION PARAMETERS				
--	Thrust chamber injector dome No. 1 vibration	0-150g rms		
--	Thrust chamber injector dome No. 2 vibration	0-150g rms		
--	Thrust chamber injector dome No. 3 vibration	0-150g rms		
--	Fuel pump inlet No. 1 vibration	0-200g rms		
--	Fuel pump inlet No. 2 vibration	0-200g rms		

(a) On engines not incorporating MD237 change.

Figure 2-19. Static-Test Instrumentation Requirements (Sheet 11 of 12)

Identification/ Instrumentation Tap	Parameter Description	Calibration Range	Error (Percent of Full Range)	Time Period/Action/Notes
ENGINE-MONITORED INSTRUMENTATION PARAMETERS (cont)				
--	Oxidizer pump No. 1 vibration	0-200g rms		
--	Oxidizer pump No. 2 vibration	0-200g rms		
--	GG spark No. 1 rate	25 milli-seconds maximum between successive sparks		
--	GG spark No. 2 rate	25 milli-seconds maximum between successive sparks		
--	ASI spark No. 1 rate	25 milli-seconds maximum between successive sparks		
--	ASI spark No. 2 rate	25 milli-seconds maximum between successive sparks		

Figure 2-19. Static-Test Instrumentation Requirements (Sheet 12 of 12)

2.5.18 ENGINE OPERATING LIMITS. Requirements for stage static test engine operating limits are outlined in figure 2-20. Requirements for operating limits are as follows:

a. All engine operating limits (minimum and/or maximum values or conditions) are required. Verification that the values or conditions remain within the limits specified is required.

b. Minimum and/or maximum values are required instrumentation and are assigned to any engine element or operational support element required to meet a specified condition, to gain maximum assurance of acceptable system performance. It is mandatory that at least one method exists for verifying each engine operating limit.

c. Unless otherwise specified, the engine operating limits as listed apply to each engine.

2.5.19 PURGE CONTROL VALVE OPERATION. On engines incorporating MD383 or MD384 change, venting from the purge control valve drain line during purge control valve operation is normal.

Venting occurs whenever back pressure builds up behind the drain line orifice. This condition may prevent the purge control valve from traveling to the full open position, which is acceptable.

2.5.20 OXIDIZER TURBOPUMP PRIMARY SEAL DRAIN LINE BURST DIAPHRAGM CONSTRAINT. The oxidizer turbopump primary seal drain line burst diaphragm assembly must be replaced if exposure to a differential pressure exceeding 10 psi is suspected.

2. 5. 18 ENGINE OPERATING LIMITS. Requirements for stage static test engine operating limits are outlined in figure 2-20. Requirements for operating limits are as follows:

a. All engine operating limits (minimum and/or maximum values or conditions) are required. Verification that the values or conditions remain within the limits specified is required.

b. Minimum and/or maximum values are required instrumentation and are assigned to any engine element or operational support element required to meet a specified condition, to gain maximum assurance of acceptable system performance. It is mandatory that at least one method exists for verifying each engine operating limit.

c. Unless otherwise specified, the engine operating limits as listed apply to each engine.

Instrumentation Tap	Description	Operating Values		Time Period/Action/Notes
		Minimum	Maximum	
	ENGINE PRE-START			
Engine/stage interface	Oxidizer inlet pressure	See figure 2-5.		
Engine/stage interface	Oxidizer inlet NPSH	See figure 2-5.		
Engine/stage interface	Fuel inlet pressure	See figure 2-9.		
Engine/stage interface	Fuel inlet NPSH	See figure 2-9.		
POT3	Oxidizer turbopump discharge temperature	See figure 2-8.		Oxidizer circulation flowrate and duration must be sufficient to obtain 3° F subcooled or colder in oxidizer high-pressure duct before engine start.
Engine/stage interface	Oxidizer and fuel inlet pressure	See notes.		The relationship between engine oxidizer and fuel inlet pressures must be within safe start region of figure 2-7.
TF1	Start tank pressure	See figure 2-11.		
TFT1	Start tank temperature	See figure 2-11.		

Figure 2-20. Static-Test Operating Limits (Sheet 1 of 4)

Instrumentation Tap	Description	Operating Values		Time Period/Action/Notes
		Minimum	Maximum	
	ENGINE PRE-START			
Engine/stage interface	Oxidizer inlet pressure	See figure 2-5.		
Engine/stage interface	Oxidizer inlet NPSH	See figure 2-5.		
Engine/stage interface	Fuel inlet pressure	See figure 2-9.		
Engine/stage interface	Fuel inlet NPSH	See figure 2-9.		
POT3	Oxidizer turbopump discharge temperature	See figure 2-8.		Oxidizer circulation flowrate and duration must be sufficient to obtain 3° F subcooled or colder in oxidizer high-pressure duct before engine start.
Engine/stage interface	Oxidizer and fuel inlet pressure	See notes.		The relationship between engine oxidizer and fuel inlet pressures must be within safe start region of figure 2-7.
TF1	Start tank pressure	See figure 2-11.		
TFT1	Start tank temperature	See figure 2-11.		

Figure 2-20. Static-Test Operating Limits (Sheet 1 of 4)

Instrumentation Tap	Description	Operating Values		Time Period/Action/Notes
		Minimum	Maximum	
	ENGINE PRE-START (cont)			
NN1	Helium tank pressure	2,800 psia	3,450 psia	
NNT1	Helium tank temperature	See notes.		Within same temperature range as start tank temperature.
--	Ignition bus and control bus	Voltage required to maintain a minimum of 24 vdc during start load conditions	31 vdc	During initial application of voltage to engine buses, maximum allowable voltage is 32 vdc for a period not to exceed 60 seconds. Ignition bus voltage requirements are for a 5.02-second maximum interval following engine-start command (based on a one-second fuel lead).
--	PU valve position(d)	Null -2°	Null +2°	The null ±2° position must be maintained until 5 seconds after STDV open control signal. Power must be supplied to fixed-phase winding of PU valve for a minimum period of 30 minutes before engine-start command.
--	MRCV position(e)	See notes.		On engine incorporating MD371 change, low EMR command must be given pre-start and maintained until 5 seconds after STDV open control signal. On engines incorporating MD366 change, the MRCV must be maintained in the high EMR position until 5 seconds after STDV open control signal.
CS1	Thrust chamber jacket temperature	-300° F	-150° F	Use maximum temperature of -80° F for 3 second fuel lead.
	ENGINE START TO ENGINE SHUTDOWN			
Engine/stage interface	Oxidizer inlet pressure and temperature	See notes.		Must be maintained to meet requirements of figure 2-6.
Engine/stage interface	Fuel inlet pressure and temperature	See notes.		Must be maintained to meet requirements of figure 2-10.

(d) Engines not incorporating MD366 or MD371 change.
(e) Engines incorporating MD366 or MD371 change.

Figure 2-20. Static-Test Operating Limits (Sheet 2 of 4)

Instrumentation Tap	Description	Operating Values		Time Period/Action/Notes
		Minimum	Maximum	
		ENGINE START TO ENGINE SHUTDOWN (cont)		
---	Diffuser coolant pressure	20 psig	--	Pressure measured at diffuser instrumentation boss. On SII stage, a single measurement for all five diffusers is allowable provided measurement can be used to determine when pressure decreases below 20 psig in any one diffuser. On engines not incorporating MD366 or MD371 change, if diffuser coolant pressure drops below 20 psig, terminate test or command engine to a minimum mixture ratio of 5.0 within 5 seconds. On engines incorporating MD371 change, if diffuser coolant pressure drops below 20 psig, terminate test or make sure MRCV is in high EMR (valve closed) position within 5 seconds.
GGT1	Fuel turbine inlet temperature	See notes.		Automatic cutoff function provided by GG hi-lo temperature cutoff unit. Minimum of 180° ±30° F within 0.5 second of mainstage control signal. GG hi-lo temperature cutoff units incorporating MD2 change provide the capability of attaining a lower temperature setting of 150° ±30° F. Maximum of 2,000° ±50° F between 0.5 and 3.5 seconds of mainstage control signal, maximum of 1,450° ±50° F for remainder of test.
PFV	Fuel turbopump	--	29,000 rpm(a) (5,800 ±50 Hz) 28,000 rpm(b) (5,680 ±50 Hz)	Automatic cutoff function provided by spark monitor overspeed cutoff panel required for initial test of an engine in a stage, for initial test following major component or calibration orifice replacement, and when an operational condition exists which could result in termination of test by a fuel depletion cutoff.

(a) 230K engines.
(b) 225K engines.

Figure 2-20. Static-Test Operating Limits (Sheet 3 of 4)

Instrumentation Tap	Description	Operating Values Minimum	Operating Values Maximum	Time Period/Action/Notes
		ENGINE START TO ENGINE SHUTDOWN (cont)		
NN1	Helium tank pressure	500 psia	3,460 psia	Helium tank may be repressurized to prevent exceeding minimum limit.
CG1	Thrust chamber pressure or outrigger loads	See notes.		On engines not incorporating MD366 or MD371 change, cutoff must be initiated if PU valve is not maintained between -2 and +30 degrees until 730 psia thrust chamber pressure is observed.(c) Thrust chamber pressure of 730 psia must be observed prior to outrigger detachment.(c) When outrigger loads are not measured, engine operation must be terminated 10 seconds after STDV signal if 730 psia thrust chamber pressure has not been observed.(c) When outrigger loads are measured, engine operation must be terminated if side loads greater than ±3,000 pounds persist or recur for an interval of 10 seconds after STDV signal plus 10 seconds, when measured on a graphic recorder with a frequency response of approximately 2-10 Hz.
--	Vibration safety cutoff	See notes.		Cutoff level of 150g rms at 960-6,000 Hz, with 70-millisecond delay time and 350-millisecond storage time (accumulative). Three vibration safety cutoff units must be wired in a ternary system, which will require a cutoff signal from any two of the three units to effect an engine cutoff. Failure of only one unit must not effect an engine cutoff.

(c) Pressure of 730 psia is applicable to sea-level operation. Observed or recorded measurement is 15 psi greater than actual due to purge bias effect.

Figure 2-20. Static-Test Operating Limits (Sheet 4 of 4)

2.6 DOCUMENTATION REQUIREMENTS.

2.6.1 ENGINE LOG BOOK ENTRIES. An Engine Log Book must be maintained for each engine to provide accurate and current records. The custodian of the engine must maintain the Engine Log Book and verify that entries are made for those requirements specified in sections I and II. The Engine Log Book must accompany the engine whenever the engine is transferred.

2.6.2 UNSATISFACTORY CONDITION REPORT SUBMITTAL. An Unsatisfactory Condition Report (UCR) must be prepared by Engine Contractor Field Engineering personnel to report all significant discrepancies on a part, component, or engine. Detailed discrepancy information that is required to complete the UCR must be provided, if applicable, by the Stage Contractor. Engine-associated UCRs must be recorded in the Engine Log Book.

2.6.3 CHECKOUT DATA. During the performance of authorized tests specified in section I, test results must be recorded and submitted to the Engine Contractor upon request for entry in the Engine Log Book.

2.6.4 STATIC TEST AND FLIGHT DATA.

2.6.4.1 Static Test Engine Operating Limit Parameters. The test data on which engine operating limit parameters were recorded must be examined to determine if any engine system is performing near its minimum or maximum established limit. If an engine system with an established operating limit is performing near its operating limit, the Engine Contractor must be notified of this condition.

2.6.4.2 Test Instrumentation. All test instrumentation monitoring any engine parameter on high frequency, oscillograph, or scaled system must be examined for abnormalities, such as sudden shifts in any one or a combination of parameters, abnormal feed system oscillations or oscillation amplitudes, or abnormal vibration levels. A discrepancy in any test parameter must be reported to the Engine Contractor.

2.6.4.3 Data Reduction. Engine test parameters required to establish engine calibration must be reduced to altitude conditions in accordance with Stage Contractor's operating procedures for data reduction, and results submitted to the Engine Contractor.

2.7 APPLICABLE SPECIFICATIONS.

2.7.1 Throughout this manual reference is made to specifications by title and basic document number; however, in all cases the issue specified in figure 2-21 governs and, where applicable, the additional criteria for specific materials detailed in this section must be adhered to.

Specification Number	Specification Title	Manual Reference Title
MIL-C-81302B 23 December 1968	Cleaning Compound, Solvent Trichlorotrifluoroethane	Cleaning compound (MIL-C-81302)
MSFC-SPEC-384		Leak-test compound (MSFC-SPEC-384)
MIL-P-25508E[(a)] Amendment 1 30 April 1971	Propellant, Oxygen	Oxidizer (MIL-P-25508)

(a) When this material is used in engine systems, the additional criteria detailed in this section for the material must be adhered to.

Figure 2-21. Applicable Specifications (Sheet 1 of 2)

Specification Number	Specification Title	Manual Reference Title
MIL-P-27201 21 May 1959	Propellant, Hydrogen	Gaseous hydrogen or liquid hydrogen (MIL-P-27201)
MIL-P-27401B[a] 19 September 1962	Propellant Pressurizing Agent, Nitrogen	Gaseous nitrogen (MIL-P-27401)
MIL-P-8585A Amendment 1 23 February 1968	Primer Coating, Zinc Chromate	Zinc chromate primer (MIL-P-8585)
MIL-T-27602A 25 January 1965	Trichloroethylene, Oxygen Propellant Compatible	Trichloroethylene (MIL-T-27602)
MIL-T-81533A 26 September 1967	1,1,1 Trichloroethane (Methyl Chloroform) Inhibited, Vapor Degreasing	Trichloroethane (MIL-T-81533)
PPP-T-0060C Amendment 2 2 March 1970	Tape: Pressure-Sensitive Adhesive, Waterproof, For Packaging	Pressure-sensitive tape
Bureau of Mines,[a] Helium Grade A	Helium	Helium

(a) When this material is used in engine systems, the additional criteria detailed in this section for the material must be adhered to.

Figure 2-21. Applicable Specifications (Sheet 2 of 2)

SECTION III

OPERATING PROCEDURES

WARNING

THE FOLLOWING GROUND SUPPORT EQUIPMENT MUST BE OPERATED BY AUTHORIZED PERSONNEL TRAINED IN THE USE OF THE EQUIPMENT.

G1035, Flight Instrumentation Checkout Console
G1037, Electrical Checkout Console
G1038, Vibration Safety Cutoff Set
G1045, Spark Monitor Overspeed Cutoff Panel
G1047, GG High-Low Temp Cutoff Panel
G3104, Pneumatic Flow Tester
G3106, Pneumatic Console
G3120, Thrust Chamber Throat Plug Kit
G3121, Data Recorder Console
G4035, Engine Vertical Installer
G4064, Engine Handler
G4066, Outboard Engine Restrainer
G4070, Film-Cooled Diffuser
9016701-11, Bypass Duct Test Plate Kit
9016710-11, Hot Gas Exhaust Test Plate Kit
9016711, Fuel Turbine Torquing Wrench Kit
9016712, Oxidizer Turbine Accessory Drive Torquing Wrench Kit
9016713, Turbopump Inlet Ducts Test Plate Kit
9016723, Bypass Valve Actuation Plate Kit
9016724, 5/8-inch, 600-psig Customer Connection Test Plate Kit
9016790, Oxidizer Heat Exchanger Handler
9016796, Components Adapter Set
9017259, Oxidizer Turbine Accessory Drive Shaft Torquing Wrench Kit
9017273, 5/8-inch, 500-psig Customer Connection Test Plate Kit
9017274, 5/8-inch, 2,000-psig Customer Connection Test Plate Kit
9018840, 1-1/2-inch, 30-psig Customer Connection Test Plate Kit
9018843, 5/8-inch, 30-psig Customer Connection Test Plate Kit
9018843-11, 5/8-inch, 80-psig Customer Connection Test Plate Kit
9018846, Turbine Exhaust System Leak-Test Plate Kit
9019960, Accumulator Hose Plate Kit
9019968, Heat Exchanger Oxidizer Supply Line Test Plate Kit
9019969, Gas Generator Control Valve Test Plate Kit
9020266, Oxidizer Tank Customer Connection Pressurization Test Plate Kit
9020269, Bypass Valve Removal Toolkit
9020628, Fluid Lines Interface Support
9024460, Electrical Interface Support
9024494, LOX Turbopump Seal Cavity Drain Line Test Plate Kit
9024496, Oxidizer and Fuel Turbine Drain Line Test Adapter Kit
9024497, GG Oxidizer Purge Line Test Plate Kit
9024540, Propellant Inlet Duct Null Adjuster Set
9024998, Gas Generator Equalization Line Leak Test Adapter Kit
9025150, Inlet Duct Support Frame Installing Tool Kit
9025400-11, Pressure-Actuated Purge Valve Test Plate Kit
9025405, Calibration Pressure Switch Test Adapter Kit
9025419, Fuel Pump Leak and Flow Adapter Kit
9025424, Vent Adapter Kit
9025425, Spark Igniter Cable Pressurization Tool Kit
9025591, Resistance Test Adapter Kit
9025817, Oxidizer Turbopump Seal Cavity Drain Line Test Adapter Kit
9025826, Start Tank System Drying Manifold Kit

SCOPE. This section contains detailed procedures that may be used to perform scheduled and unscheduled activities outlined in section I. Detailed procedures in this section may be used to support engine post-maintenance checkout.

3.1 INSPECTION.

3.1.1 Visual inspection activities specified in section I, when complemented by criteria referenced in section II, require no additional instructions. Paragraph 3.1.2 provides instructions for stress corrosion inspection of primary and auxiliary flight instrumentation package transducers and mainstage OK pressure switches.

3.1.2 STRESS CORROSION INSPECTION. Inspect the areas identified in figure 3-A1 of the primary and auxiliary flight instrumentation package transducers not incorporating MD343 compression plates and base of mainstage OK pressure switches for crack-like defects caused by stress corrosion as follows:

a. Visually inspect areas for crack-like defects. Use illumination, mirrors, and magnification up to 10X where necessary to obtain better definition or to clarify suspect areas.

b. If crack-like defects exceed 0.1 inch, coordinate disposition with Rocketdyne representative.

3.1A MATERIALS.

3.1A.1 See figure 3-A2 for materials required to perform tasks specified in this manual.

3.2 UNINSTALLED-ENGINE CHECKOUT TEST PROCEDURES.

3.2.1 PREPARING ENGINE AND ENGINE CHECKOUT EQUIPMENT. The following paragraphs prepare engine checkout equipment and the engine for continuous or individual testing. Each test is complete as an individual procedure; however, tests may be performed in a series if desired. In such cases, securing procedures indicated at the end of each test may be postponed until the series of tests is complete.

a. Test equipment must be connected and prepared when specified in each test procedure. Electrical connections for test equipment are shown in figure 3-1. Engine customer connects are shown in figure 3-2.

CAUTION

Engine power must not be turned on with the spark cables disconnected since damage to equipment can result.

NOTE

All electrical consoles must be securely grounded. Grounding studs or screws are provided on the interface panels or at the base of the console.

b. Unless otherwise specified in test procedure, engine system leakage, as measured by specified test equipment, is not allowable.

NOTE

When leak-testing a flange connection provided with a leak detection port, the flowmeter must remain connected to the test port for a minimum of 10 seconds.

c. Leakage at test plate connections is allowable if no audible leakage is detected.

d. Seals should be handled with care; however, Naflex seals are to be handled with extreme caution. (Refer to R-3825-3 for detailed removal and handling procedures.)

CAUTION

On engines incorporating MD327, MD328, MD329, MD332, or MD344 change, the brass tube that looks like a brass plug must not be removed from the seal at the start tank liquid refill line flange of the ASI fuel line.

e. Using pin puller T-5044446, remove all brass plugs from leak detection ports of system to be tested before start of test. Reinstall plugs after test, using tool T-5044445.

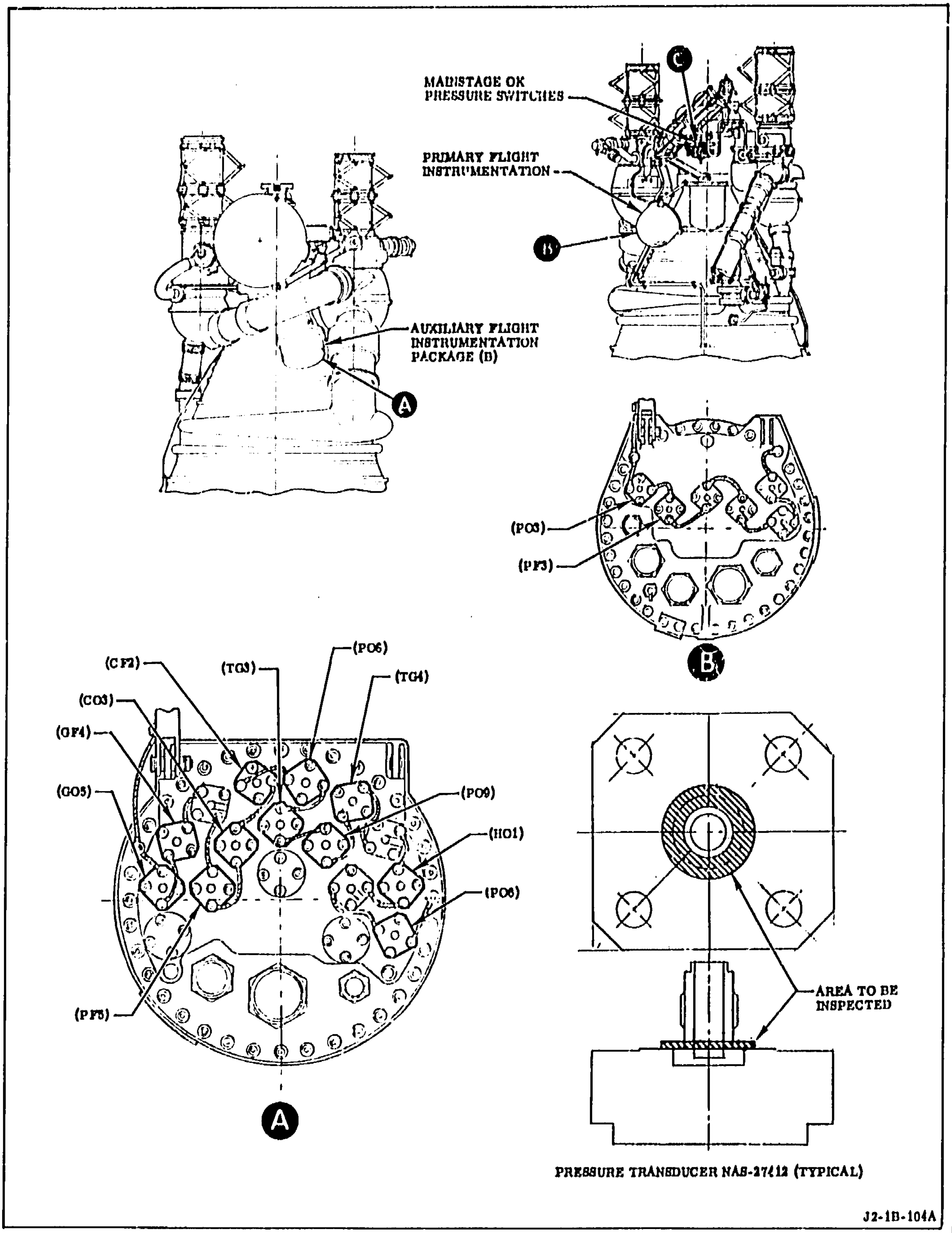


Figure 3-A1. Stress Corrosion Inspection (Sheet 1 of 2)

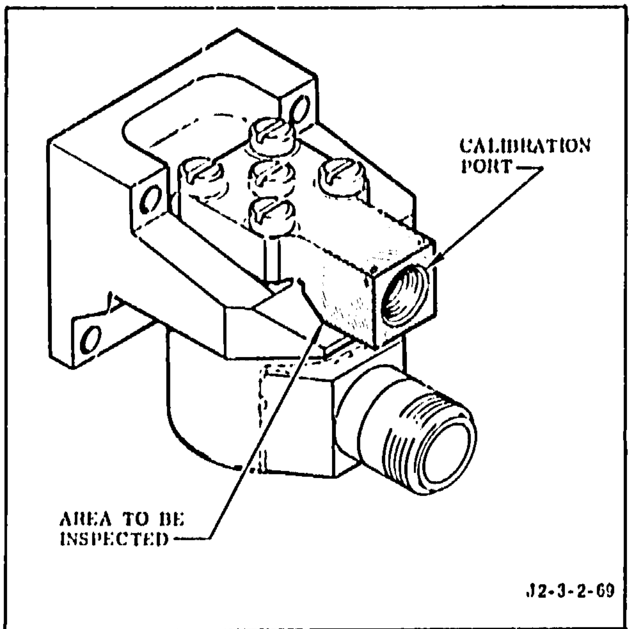


Figure 3-A1. Stress Corrosion Inspection (Sheet 2 of 2)

f. Remove threaded plugs from leak detection ports as required during system test. Reinstall plugs after test and torque to 22-28 in-lb. (Safetywire plugs after prelaunch leak test.)

3.2.1.1 Preparing Flight Instrumentation Checkout Console G1035.

WARNING

Flight Instrumentation Checkout Console G1035 must be operated by authorized personnel trained in the use of the equipment.

a. Make sure that all switches and circuit breakers are in off, neutral, or deenergized position.

b. Connect facility cable between console receptacle J200 and 115-vac, 60 Hz facility source.

Identification	Name	Use
Aclar No. 33C (Allied Chemical Corp)	Film	Protect engine ports and bagging for leak testing.
Bureau of Mines, Grade A	Helium	Service engine helium tank, purge and dry engine systems.
Handy Flux (Handy and Harman)	White flux	Braze spark igniter cable pressurizing tube.
Handy Flux Type B1 (Handy and Harman)	Black flux	Braze spark igniter cable pressurizing tube.
MIL-C-81302	Cleaning compound	Handclean engine covers and closures, wipe desiccant bags, and clean engine exterior.
MSFC-SPEC-384	Leak-test compound	Determine leaks in pressurized engine systems.
MIL-P-25508	Oxygen	Engine oxidizer.
MIL-P-27201	Hydrogen	Service engine fuel and start tank.
MIL-P-27401	Gaseous nitrogen	Pressure ECA, FI packages and spark igniter cables. Purging and drying engine systems.
MIL-P-8585	Zinc chromate primer	Coat spark igniter cable pressurizing tube to bell housing weld.
MIL-R-5031	CRES 347 filler rod or wire	Weld spark igniter cable pressurizing valve boss to tube (repairing leaking weld joint).
MIL-T-27602	Trichloroethylene	Handclean engine and thrust chamber throat plug.
MIL-T-81533	Trichloroethane	Clean engine parts.
O-T-620 (Federal Specification)	Trichloroethane	Clean engine parts.
PPP-T-60 (Federal Specification)	Waterproof tape (Was pressure-sensitive tape.)	Secure Aclar film when bagging engine ports.
Presstite Tape, Type 587.3 (Interchemical Corp)	Presstite tape	Thrust chamber throat plug installation and leak test of oxidizer turbopump primary seal burst diaphragm.

Figure 3-A2. Materials Specified in This Manual (Sheet 1 of 2)

Identification	Name	Use
RB0140-005 (Rocketdyne)	Sealing and antiseize compound	Seal threads on test plate burst diaphragm.
RB0140-012 (Rocketdyne)	Lubricant grease	Lubricate bleeder plug packings on ECA and FI packages.
RB0170-064 (Rocketdyne)	Gold-nickel brazing alloy	Repair spark igniter cable pressurizing tube to bell housing weld.
RB0170-080 (Rocketdyne)	Gold-silver-copper-zinc brazing alloy	Repair spark igniter cable pressurizing tube.
RB0195-002 (Rocketdyne)	Pressure-sensitive tape	Seal Aclar film when bagging for leak isolation and for actuating vent port check valves.
RB0265-001 (Rocketdyne)	Desiccant	Maintain correct humidity condition.
Strip Kleen No. 171 (Sinclair Paint Co)	Paint stripper	Remove zinc chromate primer when repairing spark igniter cable pressurizing tube.
Teflon Temp-R-Tape, Type C (Connecticut Hard Rubber Co)	Teflon tape	Seal thrust chamber throat plug.
0425 3UAL 9704M (Minnesota Mining and Mfg)	Aluminum tape	Actuate vent port check valves.
397 Thermocore Packing (Johns-Manville Products)	Thermocore packing	Seal film-cooled diffuser.

Figure 3-A2. Materials Specified in This Manual (Sheet 2 of 2)

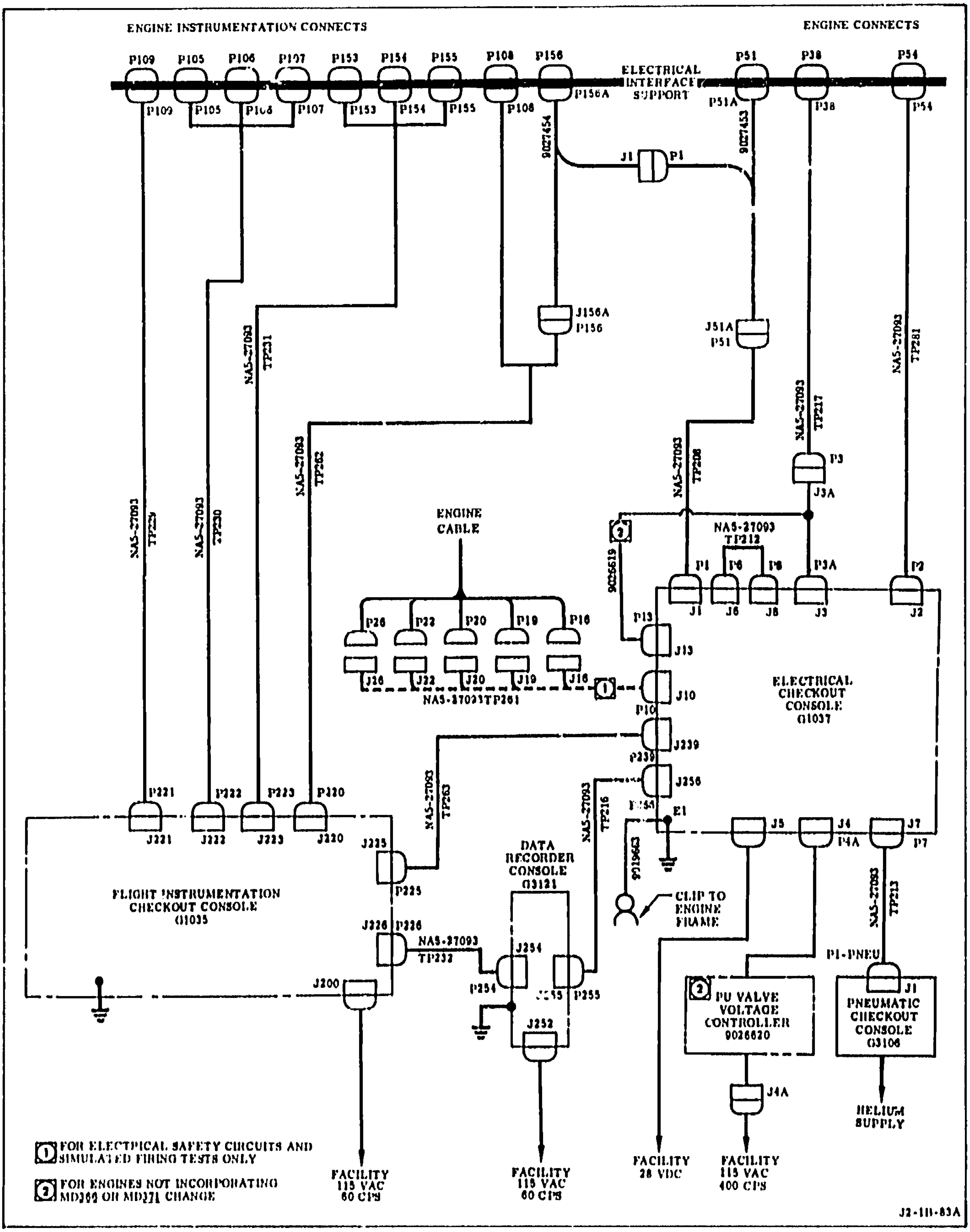


Figure 3-1. Electrical Connections for Engine Test Equipment

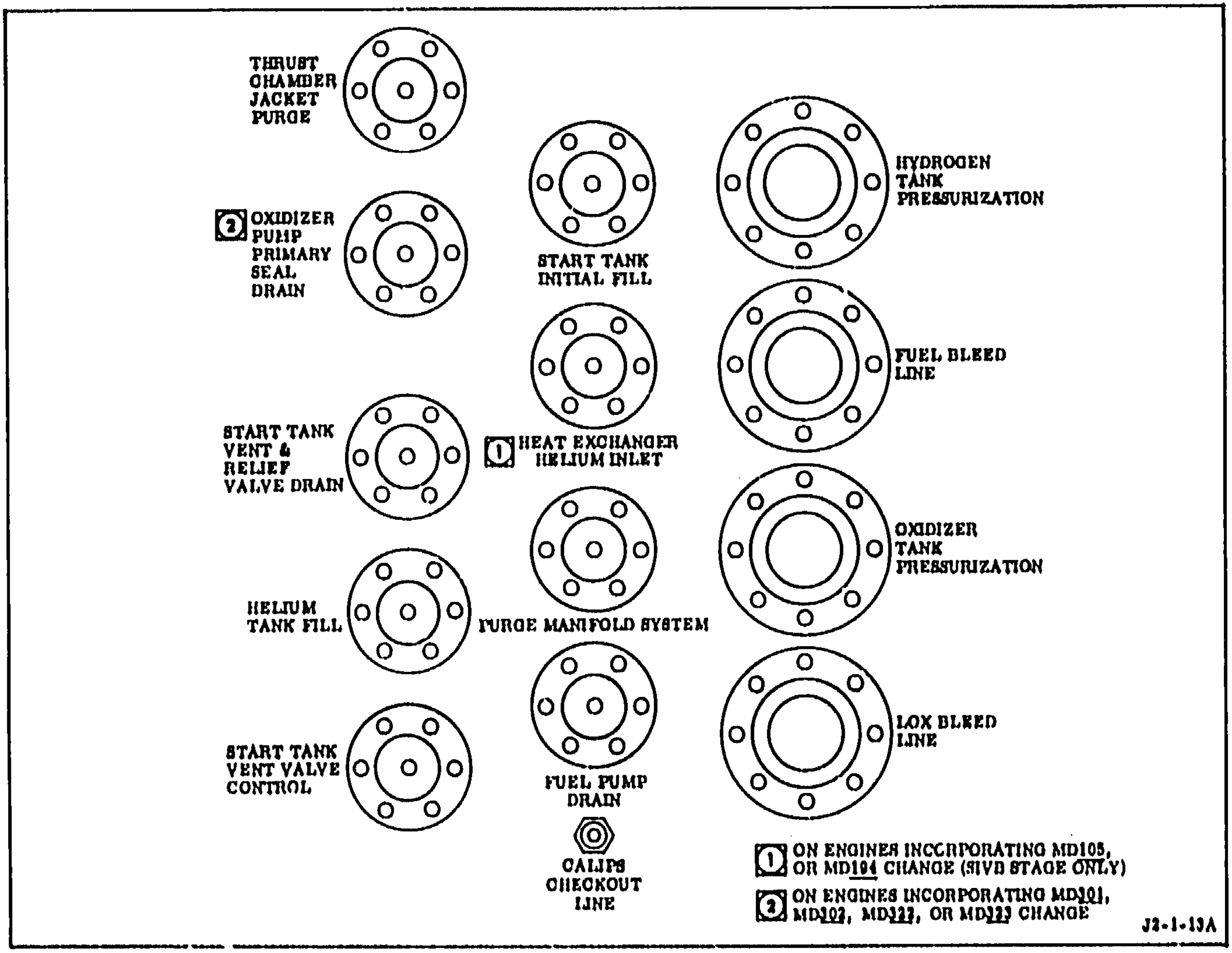


Figure 3-2. Customer Connect Locations

c. Press 115-vac and 28-vdc circuit breakers on CALIBRATION CONTROL and SIGNAL CONDITIONER panels.

d. Position switches on DIGITAL VOLT-OHMMETER panel as follows:

(1) POWER switch to PRINT.

(2) Function select switch to VDC.

(3) MODE switch to STANDBY.

e. Position switches and controls on DIGITAL RECORDER panel as follows:

(1) POWER switch to ON.

(2) RECORD switch to ON.

(3) SPACE SELECTOR dial to 1.

Operation	Result
f. Position POWER switch on DC POWER SUPPLY panel to ON.	(1) Light on DC POWER SUPPLY panel comes on. (2) STANDBY portion of CONSOLE POWER ON switch-light on CALIBRATION CONTROL panel comes on. (3) DC POWER SUPPLY panel meter should indicate 28 ±0.5 volts (adjust as necessary).

g. Make sure that current level is set at 30 amperes; adjust as necessary.

Operation	Result
h. Press CONSOLE POWER ON switch-light on CALIBRATION CONTROL panel.	(1) STANDBY portion of CONSOLE POWER ON switch-light goes off and CONSOLE POWER ON switch-light comes on. (2) 115 VAC POWER ON light on SIGNAL CONDITIONER panel comes on. (3) Digital voltohmmeter illuminates. (4) STANDBY portion of INSTRUMENT BUS POWER ON switch-light comes on.
i. Press INSTRUMENT BUS POWER ON switch-light on CALIBRATION CONTROL panel.	(1) STANDBY portion of INSTRUMENT BUS POWER ON switch-light goes off, and INSTRUMENT BUS POWER ON switch-light comes on. (2) 28 VDC POWER ON light on SIGNAL CONDITIONER panel comes on.

NOTE

Only a voltage indication is required.

Operation	Result
	(3) Two voltmeters indicate voltage.

NOTE

If RUN light comes on, it may be turned off and CALIBRATE light turned on by pressing RUN-CALIBRATE switch-light.

Operation	Result
	(4) CALIBRATE light comes on.

j. Allow a minimum warmup period of 10 minutes.

k. Pull out drawer in DIGITAL RECORDER panel to catch printout tape.

3.2.1.2 Preparing Electrical Checkout Console G1037.

NOTE

Unless otherwise specified in the test procedures, FLIGHT INST. DEENERGIZED light on SIMULATOR panel may be disregarded.

- When the electrical checkout console is set up for COMPONENT TEST, ENGINE READY on ENGINE CONTROL panel is indicated until one or more of the following occurs: operation of engine control solenoids (except helium control), sparks, or mainstage OK pressure switch. When these occur, the ENGINE READY light (ENGINE CONTROL panel) will go off and CUTOFF (ENGINE CONTROL panel) and (GROUND RELAY panel) and CUTOFF LOCKIN (ENGINE CONTROL panel) lights come on. Event Recorder pens NO. 2 (engine ready) and 30 (engine cutoff lockin) operate similarly when event recorder is monitored during tests. Pen 40 engine cutoff (vehicle) remains on as long as console is set up for COMPONENT TEST.

a. Make sure that all switches and circuit breakers are in off, neutral, or deenergized position.

[illegible]

[illegible] cable between console re- [illegible] 115-vac, 60-Hz, 25-ampere [illegible] as shown in figure 3-1.

[illegible] cables NA5-27003TP232 [illegible] to flight instrumentation [illegible] consoles as shown in figure 3-1.

[illegible] 115 VAC circuit breaker on POWER [illegible] panel.

[illegible] POWER switch on oscillograph to [illegible]

[illegible]	Result
[illegible]	Motor must stop.

[illegible] warm-up period of 10 [illegible]

NOTE

[illegible] mercury-vapor arc [illegible] may be necessary to [illegible] LAMP switch several [illegible] the arc.

[illegible] LAMP switch. Lamp must [illegible]

[illegible] INTENSITY [illegible]

[illegible] TIMING MODE selector is [illegible]

[illegible] Pneumatic Checkout Console [illegible]

[illegible] all pneumatic supply [illegible]

[illegible] LATOR fully counter- [illegible]

[illegible] valves to [illegible]

[illegible] OPEN

b. Open BLEED valves on PNEUMATIC MONITOR PANEL.

c. Connect electrical cable NA5-27093TP213 from receptacle J1 on interface panel to electrical checkout console receptacle J7. (See figure 3-1.)

d. Position controls on FLOWMETER PANEL as follows:

(1) FLOWMETER NO. 1 SHUTOFF valve to CLOSE.

(2) FLOWMETER NO. 2 SHUTOFF valve to CLOSE.

(3) FLOWMETER BYPASS valve to CLOSE.

(4) BLEED valve to OPEN.

(5) FLOWMETER LIGHT switch to ON; flowmeter lights come on.

NOTE

The four hoses 646817-4-2400 stored in the console are used for interconnecting the console and the engine as specified in detailed test procedures.

e. Obtain pressure hose 682108-6-2400 from pneumatic console HOSE STORAGE drawer and connect between HE INLET 3200 PSI MAX connection at rear of console and a 100-1,600 psig facility helium supply. Do not turn on facility helium supply until directed in test procedures.

3.2.1.6 Preparing Pneumatic Flow Tester G3104.

NOTE

When measuring flow from ports other than seal leak-test ports, using Pneumatic Flow Tester G3104, an accumulator may be used in the line from test point to flowmeter to stabilize the flowmeter indication under high flow conditions.

a. Determine atmospheric pressure (in inches of mercury) in test area.

b. Determine allowable flowrates of component being tested.

c. Open relief valve on side of case, and unlatch and remove top of case.

d. Remove the 3 adjustment legs from interior of case, and screw legs into fittings on bottom of case.

e. Lift hinged instrument panel and lock into vertical position.

NOTE

Readings for flowrates are affected by pressure against the back of the instrument panel.

f. Place tester on flat, level surface close to component being tested. Position for ease of connecting source hose to component. Under drafty conditions, face unit into draft.

g. Adjust legs on bottom of tester case until bubble on panel is exactly centered in level, indicating tester is in level position.

3.2.2 INSTALLING EXHAUST SYSTEM TEST PLATES ON UNINSTALLED ENGINES. To perform this task, proceed as follows:

a. Prepare Pneumatic Checkout Console G3106 (paragraph 3.2.1.4).

CAUTION

Adaptor 0022823 must be installed in the torque access of the fuel turbine exhaust duct any time the exhaust system test plates are installed. Failure to install adapter 0022823 can result in overpressurization of the exhaust system.

b. Remove plug and seal from torque access of fuel turbine exhaust duct, and install adapter 0022823 in torque access. Torque adapter to 50-60 in-lb. Remove pressure cap from one adapter fitting.

c. Disconnect closing control pressure line, and remove seal from OTBV.

d. Install test plate 0020251-11 from test plate kit 0016723-11 on closing control port of valve. Torque bolts to 41-45 in-lb. Make sure that bleed valve on test plate is closed.

e. If test procedures to be performed specify applying pressure to pneumatic control system (with helium control valve energized), disconnect opening control pressure line and remove OTBV seal. Install test plate 0025399 from test plate kit 0025400-11 between line and opening control port. Torque bolts to 41-45 in-lb.

f. Connect a test hose from test plate 0020251-11 to 0-1000 PSI SUPPLY OUTLET on pneumatic checkout console.

g. Adjust pneumatic supply pressure to pneumatic checkout console to 750 psig minimum.

Operation	Result
h. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until REG SUPPLY PRESSURE gage indicates 400 ±25 psig.	OTBV closes.

i. Remove flange-attaching bolts in the vicinity of 1/4-inch holes in upper and lower duct flanges to allow installation of bypass valve removal tool 0020269.

CAUTION

Extension of the lower bracket must be at a minimum to prevent distortion when installing attaching bolts.

j. Position bracket 0021015 at lower duct flange with extended portion upstream.

k. Position bracket 0021016 at upper duct flange, and install opening in bracket over extension of lower bracket 0021015. Secure both brackets using bolt AN103811 and washers LD153-0011-0014.

l. Remove nuts from remaining flange-attaching bolts.

m. Rotate hex extension of lower bracket until enough distance is obtained between duct and valve flange to allow removal of seal.

n. Withdraw remaining attaching bolts only that distance necessary to remove seal; then remove seal.

o. Install test plate 0020225 from test plate kit 0010701-11 on upstream side of bypass valve and aline with attaching bolts; then rotate hex extension to allow bellows to extend until duct flange is alined with valve.

NOTE

Tool brackets may be left installed for reinstallation of seal.

p. Install a minimum of every other attaching bolt, washer, and nut, from test plate kit 0010701-11, to ensure sealing. Torque nuts to 75-84 in-lb.

Operation	Result
q. Close REG SUPPLY valve, and open BLEED valve on PNEUMATIC SUPPLY PANEL (0-1000).	REG SUPPLY gage indicates zero.

r. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) fully counterclockwise.

NOTE

If the test hose or PNEUMATIC SUPPLY PANEL (0-1000) is needed to perform other test procedures, the hose between test plate 0020251-11 and 0-1000 PSI SUPPLY OUTLET on the pneumatic console may be disconnected.

s. Install oxidizer heat exchanger handler 0016790-11 on bellows of heat exchanger. Do not compress bellows during installation.

t. Remove bolts from downstream flange, leaving enough bolts without nuts to prevent seal and orifice from dropping when bellows is compressed.

u. Tighten handknobs on handler simultaneously until space allows removal of seal and orifice. Note orientation of seal and orifice.

v. Remove seal. Orifice installed at this location is part of calibrated exhaust system and must be left in duct.

w. Install test plate 0019860-11 from test plate kit 0010710-11 on flange; aline with bolts.

x. Loosen handknobs on handler simultaneously until bellows is fully extended.

CAUTION

Excessive movement of the H01 line can change the torque of adapter 704341, causing leakage past the seal.

y. Install a minimum of 10 bolts, washers, and nuts from test plate kit 0010710-11 and the two H01 line support clips to secure test plate 0019860-11. Torque nuts to 36-40 in-lb.

must be used), washers and nuts and the two HO1 line support clips to secure test plate 0010860-11. Torque nuts to 36-40 in-lb.

3.2.3 REMOVING EXHAUST SYSTEM TEST PLATES FROM UNINSTALLED ENGINES. To perform this task, proceed as follows:

a. Connect Electrical Checkout Console G1037 to engine (figure 3-1).

b. Prepare Electrical Checkout Console G1037, Pneumatic Checkout Console G3100, and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.2, 3.2.1.4, and 3.2.1.5).

c. Connect a pressure hose from 0-1000 PSI SUPPLY OUTLET on pneumatic checkout console to test plate on OTBV actuator closing control port.

d. Adjust facility pressure to pneumatic checkout console to 750 psig minimum.

Operation	Result
e. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until REG SUPPLY PRESSURE gage indicates 400 ±25 psi.	Bypass valve closes.

NOTE

Steps f through n remove the test plate and reinstall the seal at the OTBV flange.

f. Remove nuts and washers from valve attaching bolts.

g. Rotate hex extension of lower bracket of valve removal tool until enough distance is obtained between valve and duct flanges to allow removal of test plate.

h. Withdraw attaching bolts only enough to remove test plate; then remove test plate.

i. Install seal and secure with attaching bolts. Do not install nuts on attaching bolts at this time.

j. Rotate hex of valve removal tool until bellows is extended.

k. Install washers and nuts on attaching bolts, and remove tool brackets. Do not torque nuts at this time.

l. Install remaining attaching bolts, washers, and nuts. Cross-torque nuts to 76-84 in-lb.

m. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

Operation	Result
n. Open bleed valve on test plate 0020251-11.	Closing control pressure vents and OTBV opens. (OTBV may not open completely because opening control pressure is not applied.)

CAUTION

Excessive movement of the HO1 line can change the torque of adapter 704341 causing leakage past the seal.

NOTE

Steps o through t remove the test plate and reinstall the heat exchanger duct flange and seal.

o. Remove nuts and washers from flange bolts and remove bolts.

p. Tighten handknobs of handler simultaneously enough to remove test plate 0010860-11; then remove test plate. Make sure orifice is installed.

q. Install bolts removed from flange during exhaust system test plate installation (paragraph 3.2.2) and install seal. Do not install nuts on attaching bolts at this time.

r. Loosen handknobs of handler simultaneously until bellows is fully extended.

s. Install washers and nuts on attaching bolts. Torque bolts to 76-84 in-lb.

t. Remove handler.

u. Disconnect pressure hose from pneumatic checkout console 0-1000 PSI SUPPLY OUTLET and test plate on OTBV closing control port; then remove test plate.

v. Install seal and connect closing control line. Torque bolts to 41-45 in-lb and safetywire.

w. Remove test plate between OTBV opening control line and opening control port. Install orifice with cupped side toward valve. Install seal and opening control line. Torque bolts to 41-45 in-lb and safetywire.

x. Remove adapter from torque access of turbine exhaust duct; then install seal and plug in torque access. Torque plug to 405-445 in-lb.

NOTE

Steps y through ba are not required if the pneumatic system will be tested subsequently.

y. Install test plate 0020275 from test plate kit 0017274 on HELIUM TANK FILL customer connect. Torque nuts to 61-75 in-lb.

z. Connect pressure hose between 0-3000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate 0020275.

aa. Remove thrust chamber exit closure, or open one dessicant access opening on cover.

ab. Remove the following protective covers and closures, as applicable:

(1) Oxidizer turbine seal drain protective cover.

(2) Oxidizer turbopump intermediate seal purge check valve vent line protective cover.

(3) Oxidizer turbopump primary seal drain protective cover (at thrust chamber exit) or, on engines incorporating MD301, MD302, MD322, or MD323 change, protective cover on OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.

(4) Purge control valve vent line protective closure on engines incorporating MD301, MD302, MD322, or MD323 change.

ac. Install test plate 9025399 from test plate kit 9025400-11 between line and inlet port of purge control valve. Torque bolts to 41-45 in-lb.

Operation	Result
ad. Position switches on engine SIMULATOR panel of electrical checkout console as follows:	
(1) PREVALVE switch to CLOSED.	
(2) FACILITY READY to READY.	FACILITY READY light on ENGINE CONTROL panel comes on.

ae. Position TEST/FIRE SELECT switch on GROUND RELAY panel of electrical checkout console to OK TO TEST.

af. Position test selector switch on ENGINE TEST/MONITOR panel of electrical checkout console to COMPONENT TEST.

Operation	Result
ag. Position ENGINE GROUND POWER switch on ENGINE CONTROL panel of electrical checkout console to ON.	(1) The following lights on ENGINE/TEST MONITOR panel come on: (a) COMPONENT TEST. (b) IGNITION BUS ARMED. (c) On engines incorporating ECA 502670-111 or -211, START TANK PRESSURIZED and START TANK DEPRESSURIZED. (2) The following lights on the ENGINE CONTROL panel come on: (a) ENGINE GROUND POWER. (b) MAINSTAGE OK NO. 1 DEPRESSURIZED.

Operation	Result
	(c) MAINSTAGE OK NO. 2 DEPRESSURIZED.
	(d) TEST.
	(e) ENGINE READY.

ah. Adjust facility pneumatic pressure to pneumatic checkout console to 1,500 psig minimum.

ai. Close BLEED valve, and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-3000).

aj. Position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to ON.	HELIUM CONTROL light comes on.

ak. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) to INCREASE until REG SUPPLY PRESSURE gage indicates 225-250 psi.

al. Position IGNITION PHASE CONTROL and MAINSTAGE CONTROL switches on ENGINE TEST/MONITOR panel to ON.	(1) IGNITION PHASE CONTROL and MAINSTAGE CONTROL lights come on.
	(2) ENGINE READY light on ENGINE CONTROL panel goes off.
am. Using pneumatic flowtester, leak-test pneumatic closing line to OTBV.	Leakage is not allowable.
an. Position IGNITION PHASE CONTROL and MAINSTAGE CONTROL switches on ENGINE TEST/MONITOR panel to OFF.	IGNITION PHASE CONTROL and MAINSTAGE CONTROL lights go off.
ao. Using pneumatic flowtester, leak-test pneumatic opening control line to OTBV.	Leakage is not allowable.

ap. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

Operation	Result
aq. Position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	HELIUM CONTROL light goes off, and pressure vents.

ar. Remove test plate 9025309 from purge control valve, and connect inlet line to valve. Torque bolts to 41-45 in-lb.

as. Position HELIUM CONTROL and MAINSTAGE CONTROL switches on ENGINE TEST/MONITOR panel to ON.	HELIUM CONTROL and MAINSTAGE CONTROL lights come on.

at. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) to increase until REG SUPPLY PRESSURE gage indicates 225-250 psi.

au. Using penumatic flowtester, leak-test purge control valve inlet line flange.	Leakage is not allowable.

av. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

aw. After all pressure in helium tank has vented, position the following switches on electrical checkout console to OFF (all lights on electrical checkout console go off):

(1) HELIUM CONTROL and MAINSTAGE CONTROL on ENGINE TEST/MONITOR panel.

(2) Test selector on ENGINE TEST/MONITOR panel.

(3) TEST/FIRE SELECT on GROUND RELAY panel.

(4) ENGINE GROUND POWER on ENGINE CONTROL panel.

ax. Disconnect test hose from pneumatic checkout console 0-3000 PSI SUPPLY OUTLET and engine test plate 9020275.

ay. Remove test plate 9020275 from HELIUM TANK FILL customer connect, and install protective covers.

az. Install thrust chamber exit closure, or close desiccant access opening on cover.

ba. Install engine protective covers removed for engine testing.

bb. Secure electrical checkout console, pneumatic checkout console, and pneumatic flowtester (paragraphs 3.2.30.2, 3.2.30.4, and 3.2.30.5).

3.2.4 TESTING FLIGHT INSTRUMENTATION SYSTEM. This procedure determines that values of engine instrumentation equipment are within specified tolerances. The reading method for printout tape is shown in figure 3-3; parameter values are listed in figure 3-4. The following test equipment is required:

a. Flight Instrumentation Checkout Console G1035.

b. Electrical Checkout Console G1037.

c. Pneumatic Checkout Console G3106.

d. Test plate 9020223 (kit 9016724).

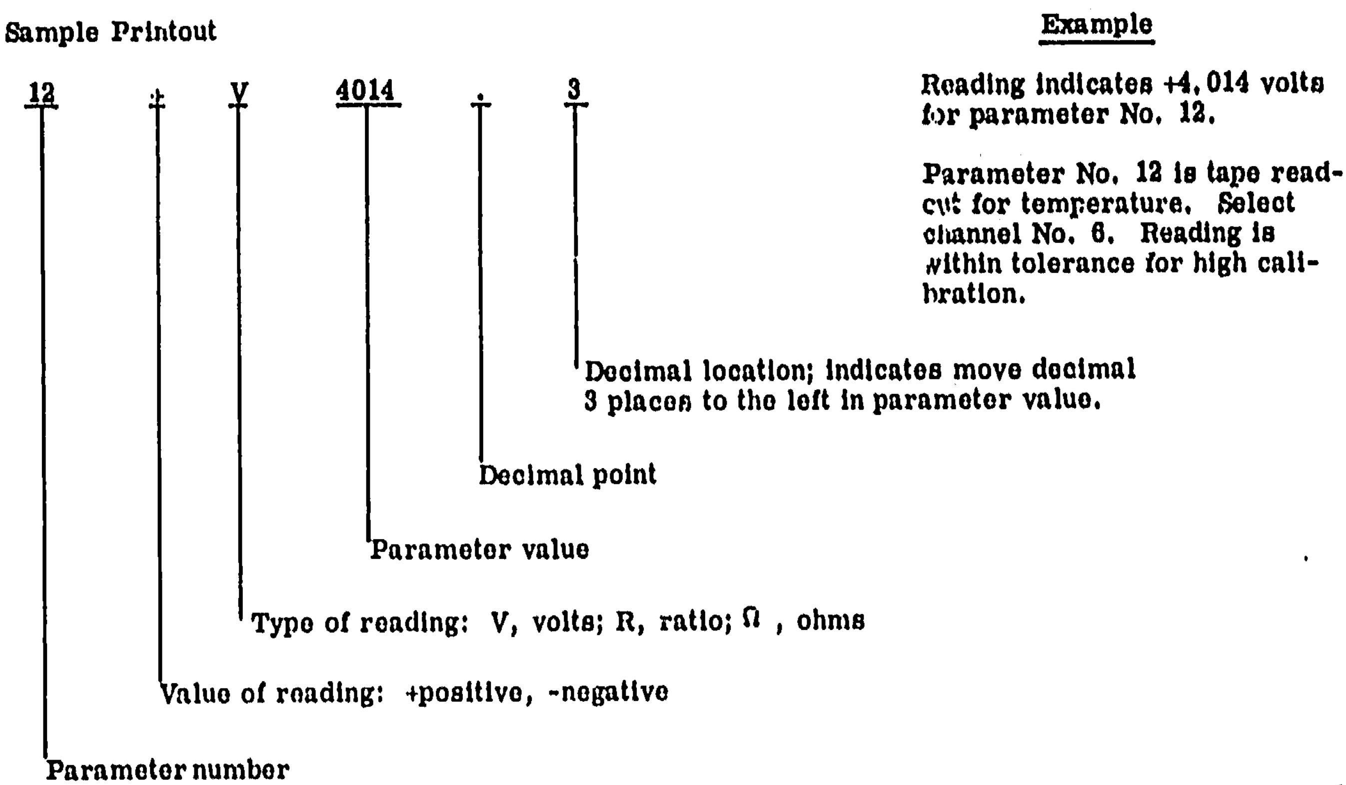


Figure 3-3. Reading Instrumentation Printout Tape

Parameter	Range (psia)	Tap Identification	Channel No.	Printer Identification	Voltage Limits: Initial Low	Initial High	Low Calibrate Low	Low Calibrate High	High Calibrate Low	High Calibrate High
PRESSURE										
Fuel pump discharge	0-1,500	PF3	1	1	-0.400	+0.500	0.600	1.500	3.600	4.500
Oxidizer pump discharge	0-1,500	PO3	2	2	-0.400	+0.500	0.600	1.500	3.600	4.500
	0-2,000[a]				-0.413	+0.437	0.587	1.487	3.587	4.487
Thrust chamber	0-1,000	CG1	3	3	-0.375	+0.525	0.625	1.525	3.625	4.525
GG chamber[q]	0-1,000	CG1	4	4	-0.375	+0.525	0.625	1.525	3.625	4.525
Fuel turbine inlet[r]	0-1,000	TG1			-0.375	+0.525	0.625	1.525	3.625	4.525
Helium tank	0-3,500	NN1	5	5	-0.428	+0.322	0.572	1.322	3.572	4.322
Start tank	0-1,500	TF1	6	6	-0.400	+0.350	0.600	1.350	3.600	4.350
Main fuel injection	0-1,000	CF2	7	31	-0.375	+0.525	0.625	1.525	3.625	4.525
	0-1,500[a]				-0.400	+0.500	0.600	1.500	3.600	4.500
Main oxidizer injection	0-1,000	CO3	8	32	-0.375	+0.525	0.625	1.525	3.625	4.525
	0-1,500[a]				-0.400	+0.500	0.600	1.500	3.600	4.500
Engine regulator outlet	0-750	NN2	9	33	-0.350	+0.550	0.650	1.550	3.650	4.550
Oxidizer turbine inlet	0-200	TG3	10	34	-0.075	+0.825	0.925	1.825	3.925	4.825
Fuel pump balance piston cavity	0-1,000	PF5	11	35	-0.375	+0.525	0.625	1.525	3.625	4.525
Oxidizer turbine outlet	0-100	TG4	12	36	+0.300	+1.200	1.300	2.200	—	—
Oxidizer pump bearing coolant[b]	0-500	PO7	13	37	-0.300	+0.600	0.700	1.600	3.700	4.600
Start tank (redundant)	0-1,500[c]	TF1	13	37	-0.400	+0.350	0.600	1.350	3.600	4.350
Start tank (redundant)	0-3,500[d]	TF1	13	37	-0.428	+0.472	0.572	1.322	3.572	4.322
Heat exchanger oxidizer inlet[e]	0-1,000	HO1	14	38	-0.375	+0.525	0.625	1.525	3.625	4.525
	0-1,500[a]				-0.400	+0.500	0.600	1.500	3.600	4.500
Helium tank (redundant)	0-3,500[f]	NN1	15	39	-0.428	+0.322	0.572	1.322	3.572	4.322
Helium tank (redundant)	0-5,000[g]	NN1	15	39	-0.435	+0.465	0.565	1.465	3.565	4.465
GG oxidizer injection	0-1,000	GO5	16	40	-0.375	+0.525	0.625	1.525	3.625	4.525
	0-1,500[a]				-0.400	+0.500	0.600	1.500	3.600	4.500
GG fuel injection	0-1,000	GF4	17	41	-0.375	+0.525	0.625	1.525	3.625	4.525
PU valve inlet	0-1,000	PO8	18	42	-0.375	+0.525	0.625	1.525	3.625	4.525
	0-1,500[a]				-0.400	+0.500	0.600	1.500	3.600	4.500
PU valve outlet	0-500	PO9	19	43	-0.300	+0.600	0.700	1.600	3.700	4.600
Oxidizer pump primary seal cavity	0-50	PO6	20	44	+1.050	+1.950	2.050	2.950	—	—
Fuel pump interstage[h]	0-200	PF6	24	63	-0.075	+0.825	0.925	1.825	3.925	4.825

(a) Engines incorporating MD172 change.
(b) Engines not incorporating MD269, MD282, MD296, MD313, MD314, or MD315 change.
(c) Engines incorporating MD269 change.
(d) Engines incorporating MD282, MD296, MD313, MD314, or MD315 change.
(e) Engines not incorporating MD105 or MD194 change.
(f) Engines incorporating MD269, MD296, or MD314 change.
(g) Engines incorporating MD282, MD313, or MD315 change.
(h) Tap removed on engines incorporating MD233 change.
(q) Engines not incorporating MD237 change.
(r) Engines incorporating MD237 change.

Figure 3-4. Flight Instrumentation Calibration Values (Sheet 1 of 3)

Parameter	Range (°F)	Tap Identification	Channel No.	Printer Identification	Voltage Limits: Initial Low	Initial High	Low Calibrate Low	Low Calibrate High	High Calibrate Low	High Calibrate High	High-Low Calibrate High	High-Low Calibrate Low
TEMPERATURE												
Fuel injection	-425 to +100	CFT2	1	7	4.050	5.400	0.668	1.088	3.898	4.298		
Thrust chamber jacket No. 2	-425 to +100	CS1a	2	8	4.050	5.400	0.688	1.088	3.898	4.298		
Thrust chamber jacket No. 1	-425 to +100	CS1	3	9	4.050	5.400	0.688	1.088	3.898	4.298		
Oxidizer turbine outlet(k)	0-1,000	TGT4	4	10	0.000	0.660	0.900	1.300	3.823	4.223		
Oxidizer turbine inlet(l)	0-1,200	TGT3	5	11	0.000	0.558	0.870	1.270	3.660	4.060		
Fuel turbine inlet(l)	0-1,800	TGT1	6	12	0.000	0.400	0.925	1.325	3.780	4.180		
Oxidizer pump discharge	-300 to -250	POT3	7	13	>5.000	>5.000	0.875	1.275	3.750	4.150	3.280	3.730
Fuel pump discharge	-425 to -400	PFT1	8	14	>5.000	>5.000	0.402	0.802	3.415	3.815	1.310	1.910
Start tank gas	-350 to +100	TFT1	9	15	3.960	5.400	0.920	1.320	3.910	4.310		
Helium tank gas	-350 to+100	NNT1	10	16	3.960	5.400	0.920	1.320	3.910	4.310		
Primary FI package	-300 to +200		11	17	3.027	4.166	0.875	1.275	3.750	4.150		
ECA No. 1	-300 to +200		12	18	3.027	4.166	0.875	1.275	3.750	4.150		
Auxiliary FI package	-300 to +200		13	45	3.027	4.166	0.875	1.275	3.750	4.150		
Heat exchanger oxidizer outlet(m) (n)	-200 to +500	HOT2	14	46	1.450	2.450	0.897	1.320	3.875	4.275		
Thrust chamber skin temperature No. 1(o)	-425 to +100	CS2										
Fuel bleed valve	-425 to -375	GFT1	15	47	>5.000	>5.000	0.240	0.640	3.248	3.648	2.707	3.157
Fuel bleed valve	-425 to -375	GFT1	16	48	>5.000	>5.000	0.240	0.640	3.248	3.648	2.707	3.157
Oxidizer bleed valve(p) (q)	-300 to -250	GOT2	17	49	>5.000	>5.000	0.875	1.275	3.750	4.150	3.280	3.730
Oxidizer bleed valve	-300 to -250	GOT2	18	50	>5.000	>5.000	0.875	1.275	3.750	4.150	3.280	3.730
Oxidizer pump bearing coolant	-300 to -250	POT4	19	51	>5.000	>5.000	0.875	1.275	3.750	4.150	3.280	3.730
Fuel pump bearing(r) (p) (q)	-425 to -325	PST1	20	52	>5.000	>5.000	0.215	0.615	3.422	3.822		
Thrust chamber skin temperature No. 2(s)	-425 to +100	CS2a										
Oxidizer pump discharge	-300 to -250	POT3	21	53	>5.000	>5.000	0.875	1.275	3.750	4.150	3.280	3.730
Fuel pump discharge	-425 to -400	PFT1	22	54	>5.000	>5.000	0.402	0.802	3.415	3.815	1.310	1.910
Start tank gas	-300 to +100	TFT1	23	55	3.960	5.400	0.920	1.320	3.910	4.310		
Heat exchanger oxidizer outlet(m)	-200 to +500	HOT2	24	56	1.450	2.450	0.897	1.297	3.865	4.265		
ECA No. 2	-300 to +200		26	58	3.027	4.166	0.875	1.275	3.750	4.150		

(k) Engines not incorporating MD263 or MD355 change.
(l) Engines not incorporating MD263 change.
(m) Engines not incorporating MD100 change.
(n) Engines not incorporating MD170 change.
(o) Engines incorporating MD170 change.
(p) Engines not incorporating MD200 change.
(q) Engines not incorporating MD248 change.
(r) Engines not incorporating MD172 change.
(s) Engines incorporating MD200 change.

Figure 3-4. Flight Instrumentation Calibration Values (Sheet 2 of 3)

Parameter	Range	Tap Identification	Channel No.	Printer Identification	Voltage Limits: Initial Low	Initial High	Low Calibrate Low	Low Calibrate High	High Calibrate Low	High Calibrate High
VALVE POSITIONS										
MFV position	0-100%		1	19	0.100	0.900				
MOV position	0-100%		2	20	0.100	0.900				
GG control valve position	0-100%		3	21	0.100	0.900				
STDV position	0-100%		4	22	0.100	0.900				
OTBV position	0-100%		5	23	4.100	4.900				
PU valve position (t)	0-100%		6	24	0.010	0.500				
MRCV position (u)	0-100%		6	24	0.090	0.890				
MRCV position (v)	0-100%		6	24	1.480	1.980				
SPEED AND FLOW										
Fuel pump speed (above cutoff)	0-30,000 rpm		1	25	4.430	4.930				
Fuel pump speed (below cutoff)	0-30,000 rpm		2	26	4.170	4.670				
Oxidizer pump speed (above cutoff)	0-12,000 rpm		3	27	4.750	5.250				
Oxidizer pump speed (below cutoff)	0-12,000 rpm		4	28	3.990	4.490				
Main fuel flowrate	0-9,000 gpm		5	29	3.080	3.580				
Main oxidizer flowrate	0-3,000 gpm		6	30	3.080	3.580				

(t) Engines not incorporating MD366 or MD371 change.
(u) Engines incorporating MD371 change.
(v) Engines incorporating MD366 change.

Figure 3-4. Flight Instrumentation Calibration Values (Sheet 3 of 3)

Parameter	Range	Tap Identification	Channel No.	Printer Identification	Voltage Limits: Initial Low	Initial High	Low Calibrate Low	Low Calibrate High	High Calibrate Low	High Calibrate High
VALVE POSITIONS										
MFV position	0-100%		1	19	0.100	0.900				
MOV position	0-100%		2	20	0.100	0.900				
GG control valve position	0-100%		3	21	0.100	0.900				
STDV position	0-100%		4	22	0.100	0.900				
OTBV position	0-100%		5	23	4.100	4.900				
PU valve position	0-100%		6	24	0.010	0.500				
SPEED AND FLOW										
Fuel pump speed (above cutoff)	0-30,000 rpm		1	25	4.430	4.930				
Fuel pump speed (below cutoff)	0-30,000 rpm		2	26	4.170	4.670				
Oxidizer pump speed (above cutoff)	0-12,000 rpm		3	27	4.750	5.250				
Oxidizer pump speed (below cutoff)	0-12,000 rpm		4	28	3.990	4.490				
Main fuel flowrate	0-9,000 gpm		5	29	3.080	3.580				
Main oxidizer flowrate	0-3,000 gpm		6	30	3.080	3.580				

Figure 3-4. Flight Instrumentation Calibration Values (Sheet 3 of 3)

3.2.4.1 Preparing For Test.

a. Prepare Flight Instrumentation Checkout Console G1035 (paragraph 3.2.1.1).

b. Connect Flight Instrumentation Checkout Console G1035 to engine electrical connections (figure 3-1). See figure 3-2 for location of customer connects.

3.2.4.2 Calibration-Testing Pressure Parameters.

Operation	Result
a. Press PRESSURE SELECT switch-light on CALIBRATION CONTROL panel.	PRESSURE SELECT switch-light comes on.
b. Press CHANNEL NO. 1 button in PRESSURE TEST section of CALIBRATION CONTROL panel.	(1) CHANNEL NO. 1 button lights. (2) DIGITAL VOLT-OHMMETER indicates transducer output voltage. (3) Printer prints initial voltage value on tape.
c. Press and hold LOW CALIB. TEST switch-light on CALIBRATION CONTROL panel until result is obtained.	Switch-light comes on, and printer prints low-calibrate voltage value.
d. Press and hold HIGH CALIB. TEST switch-light on CALIBRATION CONTROL panel until result is obtained.	Switch-light comes on, and printer prints high-calibrate voltage value.
e. Press RELEASE button in PRESSURE TEST section of CALIBRATION CONTROL panel.	CHANNEL NO. 1 button releases, and light goes off.
f. Check the initial (ambient), low-calibrate, and high-calibrate readouts.	Readouts must be within voltage limits specified in figure 3-4.

g. Repeat steps b through f for pressure channels 2 through 20 and 24. Where CHANNEL NO. 1 is specified, select next applicable channel.

h. Refer to Engine Log Book and calculate difference in voltage (ΔE) between initial (ambient) and low-calibrate readouts recorded during engine final acceptance checkout (form DD250 signoff) for oxidizer pump primary seal cavity parameter (PO6) and oxidizer turbine outlet parameter (TG4). For all other pressure parameters, calculate difference in voltage (ΔE) between low-calibrate and high-calibrate readouts.

NOTE

If transducer has been replaced in the field, new values recorded in Engine Log Book must be used during first calibration test after transducer replacement.

i. For oxidizer pump primary seal cavity parameter (PO6) and oxidizer turbine outlet parameter (TG4), calculate difference in voltage (ΔE) between initial readout (step b) and low-calibrate readout (step c). The voltage difference (ΔE) must be within ±0.100 vdc of the corresponding ΔE calculated in step h from the initial and low-calibrate readouts. For all other pressure parameters, calculate the difference in voltage (ΔE) between the low-calibrate readout (step c) and high-calibrate readout obtained in step d. The voltage difference (ΔE) must be within ±0.100 vdc (±2 percent of 5 vdc full scale) of the corresponding ΔE calculated in step h from the low- and high-calibrate readouts.

j. Example of voltage difference (ΔE) calculation (step i):

	Voltage Readouts (vdc)		
	Low Calibrate	High Calibrate	Calculated ΔE
(1) Readouts recorded in Engine Log Book	1.495	4.494	2.999
(2) Readouts obtained during this test	1.499	4.500	3.001
(3) Difference between calculated ΔE values in substeps 1 and 2 (must be within ±0.100 vdc)			0.002

k. If helium tank or start tank parameter is tested and voltage is not within tolerance, pressure may exist in tank. If pressure exists, vent tank and retest parameter. To vent start tank and retest start tank parameter, perform steps l through u. To vent helium tank and retest helium tank parameter, perform steps v through z.

l. Install test plate 9020223 on START TANK VENT VALVE CONTROL customer connect. Torque bolts to 61-75 in-lb. Connect a test hose from test plate to 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console.

m. Remove closure from START TANK VENT & RELIEF VALVE DRAIN customer connect.

n. Prepare Pneumatic Checkout Console G3106 (paragraph 3.2.1.4).

o. Adjust facility pneumatic pressure to checkout console to 300 psig minimum.

WARNING

Failure to observe the safety requirements of step p can result in injury to personnel.

Operation	Result
p. Clear all personnel from area of START TANK VENT & RELIEF VALVE DRAIN customer connect; then using PNEUMATIC SUPPLY PANEL (0-1000), pressurize start tank vent valve control to 250 psig maximum.	Any pressure in start tank must vent through START TANK VENT & RELIEF VALVE DRAIN customer connect.

q. After all pressure has vented, decrease pressure to start tank vent valve control to zero.

r. Disconnect test hose from test plate on START TANK VENT VALVE CONTROL customer connect and 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console.

s. Remove test plate from START TANK VENT VALVE CONTROL customer connect.

t. Install protective covers on START TANK VENT VALVE CONTROL and START TANK VENT & RELIEF VALVE DRAIN customer connects.

u. Unless pneumatic checkout console is required for another test, secure console (paragraph 3.2.30.4).

v. Repeat calibration test for start tank parameter.

w. Connect test cable NA5-27093TP208 between receptacle J1 of electrical checkout console and engine connector P51. (Connect engine electrical connectors in accordance with R-3825-3.)

x. Prepare Electrical Checkout Console G1037 (paragraph 3.2.1.2).

Operation	Result
y. Position EMERG HELIUM TANK VENT switch on ENGINE CONTROL panel to ON. After all venting has stopped, position EMERG HELIUM TANK VENT switch to OFF.	EMERG HELIUM TANK VENT light comes on, and any pressure in helium tank starts venting.

z. Repeat calibration test for helium tank parameter.

aa. Unless electrical checkout console is required for another test, secure console (paragraph 3.2.30.2) and remove cable connected for this test.

3.2.4.3 Calibration-Testing Temperature Parameters.

Operation	Result
a. Press TEMPERATURE SELECT switch-light on CALIBRATION CONTROL panel.	TEMPERATURE SELECT switch-light comes on, and PRESSURE SELECT switch-light goes off.
b. Press CHANNEL NO. 1 button in TEMPERATURE TEST section of CALIBRATION CONTROL panel.	(1) CHANNEL NO. 1 button lights.
	(2) DIGITAL VOLTOHMMETER indicates transducer output voltage.
	(3) Printer prints transducer output voltage value on tape.
c. See figure 3-4 and compare printer reading with initial voltage limits opposite channel 1 of temperature section.	Reading must be within specified limits.

Operation	[illegible]
d. Press and hold LOW CALIB. TEST switch-light on CALIBRATION CONTROL panel until result is obtained.	[illegible]

e. See figure 3-4 and compare printer reading with low-calibrate voltage [illegible] opposite channel 1 of temperature section. [illegible] calibrate voltage readings are not within limits, signal conditioner panel [illegible] adjustment as outlined in [illegible] instrumentation [illegible] R-[illegible]. After adjustment, repeat calibration test of temperature parameters.

Operation	Result
f. Press and hold HIGH CALIB. TEST switch-light on CALIBRATION CONTROL panel until result is obtained.	[illegible] high calibration voltage [illegible]

g. See figure 3-4 and compare printer reading with high-calibrate voltage limits opposite channel 1 of temperature section. [illegible] calibrate voltage readings are not within limits, signal conditioner panel [illegible] adjustment as outlined in [illegible] instrumentation [illegible] R-[illegible]. After adjustment, repeat calibration test of temperature parameters.

Operation	Result
h. Press RELEASE button in TEMPERATURE TEST section of CALIBRATION CONTROL panel.	CHANNEL NO. 1 button [illegible] light goes off.

i. Repeat steps b through [illegible] for [illegible] channels 2 through [illegible] and [illegible]. Where [illegible] NO. 1 is specified, select [illegible] channel.

Operation	Result
j. Press CHANNEL NO. 7 button in TEMPERATURE TEST section of CALIBRATION CONTROL panel. Disregard DIGITAL VOLTOHMMETER and printer indication.	CHANNEL NO. 7 button lights.

[illegible]

[illegible] cutting speed and flow [illegible]

[illegible] | [illegible] AND FLOW SELECT [illegible] and VALVE [illegible] SELECT light [illegible]

[illegible] DIGITAL VOLTMETER [illegible]

[illegible] DIGITAL VOLT-METER [illegible]

[illegible] | DIGITAL VOLTMETER indicates [illegible] of output voltage and greater positive voltage [illegible]

[illegible]

j. Disconnect plug P109 of test cable NA5-27093TP229 from cable adapter 9024512.

k. Connect test cable 9025117 from plug P109 of test cable NA5-27093TP229 to static-stage fuel flowmeter connector J110A and static-stage oxidizer flowmeter connector J111A.

l. Position POWER switch on DC POWER SUPPLY panel to ON.

m. Repeat steps b through g for channels 5 and 6. Where CHANNEL NO. 1 is specified, select next applicable channel.)

Operation	Result
n. Press SPEED AND FLOW SELECT switch-light on CALIBRATION CONTROL panel.	SPEED AND FLOW SELECT light goes off.
o. Press INSTRUMENT BUS POWER ON switch-light on CALIBRATION CONTROL panel.	(1) INSTRUMENT BUS POWER ON light goes off. (2) 28 VDC POWER ON light on SIGNAL CONDITIONER panel goes off. (3) STANDBY portion of INSTRUMENT BUS POWER ON switch-light comes on.
p. Press CONSOLE POWER ON switch-light on CALIBRATION CONTROL panel.	(1) CONSOLE POWER ON light goes off. (2) STANDBY portion of CONSOLE POWER ON switch-light comes on. (3) 115 VAC POWER ON light on SIGNAL CONDITIONER PANEL goes off. (4) STANDBY portion of INSTRUMENT BUS POWER ON switch-light goes off.

q. Return all switches to off or normal position, and pull out all circuit breakers.

r. Disconnect test cable from P109, J110A, and J111A.

s. Reconnect engine cable to P109. (Refer to R-3825-3.)

3.2.4.6 Securing After Test. Secure flight instrumentation checkout console (paragraph 3.2.30.1).

3.2.5 TESTING PROPELLANT UTILIZATION VALVE (ENGINES NOT INCORPORATING MD366 OR MD371 CHANGE). This test consists of positioning the PU valve to various positions and recording the position transducer movement.

3.2.5.1 Preparing for Test.

a. Connect Flight Instrumentation Checkout Console G1035, Electrical Checkout Console G1037 (connect and disconnect engine electrical connectors in accordance with R-3825-3), and Data Recorder Console G3121 (figure 3-1).

b. Connect propellant utilization valve voltage adjust and monitoring test unit 9025664 as follows:

(1) Connect wiring harness adapter 9026619 as shown in figure 3-1.

(2) Connect PU valve voltage controller 9026620 as shown in figure 3-1 unless facility power adjustment capability meets requirements of step j.

c. Connect volt/ohm/milliammeter (Model 630 NA, Triplett, or equivalent) to 115 vac, 400 cycle jacks on simulator panel. Set volt/ohm/milliammeter to 0-150 volt range.

d. Prepare flight instrumentation checkout console and electrical checkout console (paragraphs 3.2.1.1 and 3.2.1.2).

NOTE

Steps e and f apply to voltage controller 9026620.

e. Adjust facility power source to voltage controller to 115 ±5 vac, 400 Hz.

f. Adjust voltage controller dial to a scale reading of 100.

g. On DIGITAL VOLT-OHMMETER panel, position POWER switch to ON and MODE switch to CONT. SCAN.

NOTE

Steps h through l apply to the electrical checkout console.

h. Press circuit breaker on P.U. VALVE POSITION CONTROLLER panel.

Operation	Result
i. Position AC POWER ON switch on P.U. VALVE POSITION CONTROLLER panel to ON position. Do not leave P.U. VALVE POSITION CONTROLLER panel power on unless valve is being checked out.	AC POWER on light comes on.

j. Adjust voltage controller or facility power supply until volt/ohm/milliammeter indicates 110-116 volts at 115 VAC, 400 CYCLE jacks. Maintain a reading of 108-121 volts during PU valve test. To maintain voltage between 108 and 121 volts, slowly turn VALVE POSITION INPUT REFERENCE knob when making changes in PU valve position.

k. Position NOMINAL VALVE OPENING switch to VALVE OPENING.

l. Turn VALVE POSITION INPUT REFERENCE knob on P.U. VALVE POSITION CONTROLLER panel fully counterclockwise.	VALVE OPENING meter indicates zero (+10, -0) percent.

m. Prepare oscillograph of Data Recorder Console G3121 (paragraph 3.2.1.3). Oscillograph chart speed button 1 must be pressed.

Operation	Result
n. Press VALVE POSITION SELECT switch-light on CALIBRATION CONTROL panel.	VALVE POSITION SELECT light comes on.
o. Press CHANNEL NO. 6 button in VALVE POSITION test section of CALIBRATION CONTROL panel.	CHANNEL NO. 6 button lights.

3.2.5.2 Testing Position Transducer.

a. Observe VALVE OPENING meter and trace on oscillograph paper; then turn VALVE POSITION INPUT REFERENCE knob on P.U. VALVE POSITION CONTROLLER panel clockwise. Oscillograph trace should verify transducer movement to the open position.	(1) VALVE OPENING meter indicates 100 (+0, -10) percent. (2) DIGITAL VOLT-OHMMETER on flight instrumentation checkout console must indicate 4.750 ±0.250 volts.

NOTE

The oscillograph trace is used only to verify transducer movement indicated on the VALVE OPENING meter. No specific amount of deflection of the trace is required.

- Steps b through d are to be performed only when an oscillation of the PU valve is noted by an audible noise or trace on the oscillograph.

b. Open upper access door at rear of Electrical Checkout Console G1037, and remove cover from PU valve position controller panel amplifier. (Refer to R-3825-5.)

c. Slowly turn adjustment screw of amplifier located immediately behind connector Z1J1 counterclockwise until oscillations stop. Turn screw clockwise until oscillations start; then slowly turn screw counterclockwise until oscillations stop. (If adjustment screw is turned too far counterclockwise, control phase power to valve will be turned off.)

d. Reinstall amplifier cover, and close access door.

Operation	Result
e. Observe VALVE OPENING meter and trace on oscillograph paper; then turn VALVE POSITION INPUT REFERENCE knob counterclockwise. Oscillograph trace should verify transducer movement to the closed position.	(1) VALVE OPENING meter indicates zero (+10, -0) percent. (2) DIGITAL VOLT-OHMMETER on flight instrumentation checkout console must indicate 0.010 to 0.500 volt.

f. Momentarily position VALVE OPENING switch to NOMINAL VALVE OPENING. Record indication on VALVE OPENING meter.

g. Observe VALVE OPENING meter and trace on oscillograph paper; then turn VALVE POSITION INPUT REFERENCE knob clockwise until VALVE OPENING meter indicates nominal position recorded in step f. Oscillograph trace should verify transducer movement indicated on VALVE OPENING meter.

h. Stop oscillograph by pressing red ON-OFF button.

i. Position AC POWER ON switch on P.U. VALVE POSITION CONTROLLER panel to OFF.	AC POWER ON light goes off.

3.2.5.3 Securing After Test.

a. Return all switches and circuit breakers on test equipment to off, neutral, or deenergized position.

b. Secure flight instrumentation checkout console, electrical checkout console, and data recorder console (paragraphs 3.2.30.1 through 3.2.30.3), and secure PU valve voltage adjust and monitoring test unit.

3.2.5A TESTING MIXTURE RATIO CONTROL VALVE.

3.2.5A.1 Preparing for Test.

a. Connect Flight Instrumentation Checkout Console G1035, Electrical Checkout Console G1037 (connect and disconnect engine electrical connectors in accordance with R-3825-3), Pneumatic Checkout Console G3106, and Data Recorder Console G3121 (figure 3-1).

b. Prepare Flight Instrumentation Checkout Console G1035, Electrical Checkout Console G1037, Data Recorder Console G3121, and Pneumatic Checkout Console G3106 for use (paragraphs 3.2.1.1 through 3.2.1.4).

c. Install test plate 9020275 on HELIUM TANK FILL customer connect. Torque nuts to 61-75 in-lb.

d. Connect a pressure hose between 0-3000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate installed on HELIUM TANK FILL customer connect.

Operation	Result
e. Position PREVALVE switch to CLOSED and FACILITY READY switch to READY on engine SIMULATOR panel of electrical checkout console.	FACILITY READY light on ENGINE CONTROL panel comes on.

f. Position TEST/FIRE SELECT switch on GROUND RELAY panel of electrical checkout console to OK TO TEST.

g. Position test selector switch on ENGINE TEST/MONITOR panel of electrical checkout console to COMPONENT TEST.

Operation	Result
h. Position ENGINE GROUND POWER switch on ENGINE CONTROL panel of electrical checkout console to ON.	(1) The following lights on ENGINE/TEST MONITOR panel come on:
	(a) COMPONENT TEST.
	(b) IGNITION BUS ARMED.
	(c) On engines incorporating ECA 502670-211, START TANK PRESSURIZED and START TANK DEPRESSURIZED.
	(2) The following lights on ENGINE CONTROL panel come on:
	(a) ENGINE GROUND POWER.
	(b) MAINSTAGE OK NO. 1 DEPRESSURIZED.
	(c) MAINSTAGE OK NO. 2 DEPRESSURIZED.
	(d) TEST.
	(e) ENGINE READY.

i. Remove thrust chamber exit closure or open one desiccant access opening on closure.

j. Remove protective cover from oxidizer turbine seal drain line.

k. Remove protective cover from oxidizer pump seal drain line or, on engines incorporating MD301, MD302, MD322, or MD323 change, OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.

l. Remove protective cover from oxidizer turbopump intermediate seal purge check valve.

m. Adjust facility pneumatic pressure to pneumatic checkout console to 1,600 psig minimum.

n. On DIGITAL VOLT-OHMMETER panel, position POWER switch to ON and MODE switch to CONT. SCAN.

3.2.5A.2 Function Testing.

WARNING

Failure to observe the safety requirements of step a can result in injury to personnel.

a. Clear area of personnel. Personnel must stand behind adequate safety barriers or at a safe distance from engine.

b. Close BLEED valve on PNEUMATIC SUPPLY PANEL (0-3000).

c. Open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-3000).

d. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) to INCREASE until REG SUPPLY PRESSURE gage indicates 1,400-1,600 psi.

NOTE

Steps e through g apply to data recorder console.

e. Press oscillograph chart speed button 16 on RECORDING OSCILLOGRAPH panel.

Operation	Result
f. Press VALVE POSITION SELECT switch-light on CALIBRATION CONTROL panel.	VALVE POSITION SELECT light comes on.

Operation	Result
g. Press CHANNEL NO. 6 button in VALVE POSITION test section of CALIBRATION CONTROL panel.	(1) CHANNEL NO. 6 button lights. (2) DIGITAL VOLT-OHMMETER on flight instrumentation checkout console must indicate 0.49 ±0.40 volt on engines incorporating MD371 change or 1.73 ±0.25 volts on engines incorporating MD366 change.
h. Position MRC VALVE switch on ENGINE TEST/MONITOR panel to OPEN.	MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel comes on.

i. Press oscillograph red ON-OFF button.

Operation	Result
j. Position HELIUM CONTROL and MAINSTAGE CONTROL switches on ENGINE TEST/MONITOR panel to ON.	(1) Event recorder pen 4 picks up. (2) HELIUM CONTROL light comes on. (3) MAINSTAGE CONTROL light comes on. (4) MRCV and MOV move to open position.

NOTE

The mainstage control valve is energized to prevent excessive loss of helium through engine purges.

Operation	Result
k. Read DIGITAL VOLT-OHMMETER on flight instrumentation checkout console.	on engines incorporating MD371 change, voltage change from step g must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step g must be between 0.6 and 1.0 vdc.
l. Position MRC VALVE switch on ENGINE TEST/MONITOR panel to CLOSED.	(1) MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel goes off. (2) MRCV moves to closed position.

m. Read DIGITAL VOLT-OHMMETER on flight instrumentation checkout console and record value.

Operation	Result
n. Position MRC VALVE switch on ENGINE TEST/MONITOR panel to OPEN.	(1) MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel comes on. (2) MRCV moves to open position.
o. Read DIGITAL VOLT-OHMMETER on flight instrumentation checkout console.	On engines incorporating MD371 change, voltage change from step m must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step m must be between 0.6 and 1.0 vdc.
p. Position MAINSTAGE CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	MAINSTAGE CONTROL light goes off.
q. Position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	HELIUM CONTROL light goes off, and event recorder pen 4 drops out.
r. Approximately 5 seconds after step q, position MRC VALVE switch on ENGINE TEST/MONITOR panel to CLOSED.	MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel goes off.

s. Press oscillograph red ON-OFF button.

Operation	Result
t. Determine MRCV operating times.	MRCV operating times must be within limits of figure 1-11.
u. Close REG SUPPLY SHUTOFF valve and open BLEED valve on PNEUMATIC SUPPLY PANEL (0-3000).	REG SUPPLY PRESSURE gage indicates zero.
v. Position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to ON.	(1) Event recorder pen 4 picks up. (2) HELIUM CONTROL light comes on; helium tank vents.
w. After pressure has vented from helium tank, position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	HELIUM CONTROL light goes off.

3.2.5A.3 Securing After Test.

a. Return all switches and circuit breakers on test equipment to off, neutral, or deenergized position.

b. Secure flight instrumentation checkout console, electrical checkout console, data recorder console, pneumatic flow tester, and pneumatic checkout console (paragraphs 3.2.30.1 through 3.2.30.5).

c. Disconnect test hose from pneumatic checkout console 0-3000 PSI SUPPLY OUTLET and engine test plate 9020275.

d. Remove test plate 9020275 from HELIUM TANK FILL customer connect, and install protective covers.

e. Install thrust chamber exit closure, or close desiccant access cover on closure.

f. Install all protective covers and closures removed for this test.

3.2.6 TESTING ELECTRICAL SAFETY CIRCUITS. The electrical safety circuit tests are performed to determine if the engine electrical control system will terminate the sequence when a malfunction is simulated by the test equipment. A 5-minute-minimum time lapse is required between tests. When performing the electrical safety circuit tests, disregard all lights not specified in the test procedure.

WARNING

The Flight Instrumentation Checkout Console G1035 and Electrical Checkout Console G1037 must be operated by authorized personnel trained in the use of the equipment.

3.2.6.1 Preparing for Test.

a. Connect Flight Instrumentation Checkout Console G1035 and Electrical Checkout Console G1037 (figure 3-1). (Connect and disconnect engine electrical connectors in accordance with R-3825-3.)

b. Disconnect engine harness plugs (refer to R-3825-3), and install electrical cable NA5-27093TP261 between electrical checkout console receptacle J10 and the following engine harness plugs (shown as dashed line in figure 3-1):

(1) Ignition detector probe plug P19.

(2) Mainstage OK pressure switch No. 1 plug P20.

(3) Mainstage OK pressure switch No. 2 plug P26.

c. Prepare electrical checkout console for use as outlined in paragraph 3.2.1.2.

d. Position the following switches on SIMULATOR panel as indicated:

(1) FACILITY READY to READY; FACILITY READY light on ENGINE CONTROL panel comes on.

(2) PREVALVES to OPEN.

(3) MS OK PRESS SW NO. 1 and MS OK PRESS SW NO. 2 to CLOSED.

(4) IGNITION to DETECTED.

e. Position TEST/FIRE SELECT switch on GROUND RELAY panel to AREA CLEAR.

f. Position the following switches on ENGINE CONTROL panel as indicated:

(1) EMERG HELIUM TANK VENT to OFF.

(2) Switch below EMERG START TANK VENT light to CLOSED.

(3) ARMED TEMP DETECT BYPASS to ON.

Operation	Result
g. Position ENGINE GROUND POWER switch on ENGINE CONTROL panel to ON.	Voltmeter on panel indicates 24-30 vdc, and the following panel lights on electrical checkout console come on: ENGINE CONTROL panel: (1) ENGINE GROUND POWER. (2) AREA CLEAR. (3) ENGINE READY. (4) ARMED. (5) MAINSTAGE OK NO. 1 DEPRESSURIZED. (6) MAINSTAGE OK NO. 2 DEPRESSURIZED. ENGINE TEST/MONITOR panel: IGNITION BUS ARMED.

3.2.6.2 Testing for Delay in Receiving Mainstage Enable Signal. Prepare for test (paragraph 3.2.6.1).

a. (Deleted)

b. Position ARMED TEMP DETECT BYPASS switch on ENGINE CONTROL panel to OFF.

Operation	Result
c. Read steps d and e; then momentarily press ENGINE START button on ENGINE CONTROL panel.	Approximately 2 seconds after engine start signal, IGNITION COMPLETE light on ENGINE TEST MONITOR panel comes on. Engine must remain in this condition.
d. After 2 seconds in this condition, position ARMED TEMP DETECT BYPASS switch on ENGINE CONTROL panel to ON.	Engine sequence must continue to mainstage.

Operation	Result
e. Momentarily press CUTOFF button on ENGINE CONTROL panel.	Engine cutoff occurs.
f. Press CUTOFF RESET button on ENGINE CONTROL panel.	(1) CUTOFF LOCK-IN light goes off.
	(2) CUTOFF light on GROUND RELAY panel goes off.

g. Position ENGINE GROUND POWER switch on ENGINE CONTROL panel to OFF unless safety circuit testing is to be continued.

3.2.6.3 Testing for Failure to Receive Start Tank Depressurized Signal After Engine Start (Engines Incorporating Electrical Control Assembly 502670-111 or 502670-211). Prepare for test (paragraph 3.2.6.1).

a. Position START TANK switch on SIMULATOR panel to PRESSURIZED.

b. Make sure that IGNITION COMPLETE BYPASS on ENGINE TEST/MONITOR panel is OFF.

Operation	Result
c. Momentarily press ENGINE START button on ENGINE CONTROL panel.	Engine cutoff occurs 1/4 to 3/4 second after START TANK DISCH CONTROL light on ENGINE TEST/MONITOR panel comes on.
d. Press CUTOFF RESET button on ENGINE CONTROL panel.	(1) CUTOFF LOCK-IN light goes off.
	(2) CUTOFF light on GROUND RELAY panel goes off.

e. Position START TANK switch on SIMULATOR panel to DEPRESSURIZED.

f. Position ENGINE GROUND POWER switch on ENGINE CONTROL panel to OFF unless safety circuit testing is to be continued.

3.2.6.4 Testing for Failure to Receive Ignition Detected Signal After Engine Start. Prepare for test (paragraph 3.2.6.1).

a. Position IGNITION switch on SIMULATOR panel to NOT DETECTED.

Operation	Result
b. Momentarily press ENGINE START button on ENGINE CONTROL panel.	Engine cutoff occurs 1/4 to 3/4 second after START TANK DISCH CONTROL light on ENGINE TEST/MONITOR panel comes on.
c. Press CUTOFF RESET button on ENGINE CONTROL panel.	(1) CUTOFF LOCK-IN light goes off.
	(2) CUTOFF light on GROUND RELAY panel goes off.

d. Position IGNITION switch on SIMULATOR panel to DETECTED.

e. Position ENGINE GROUND POWER switch on ENGINE CONTROL panel to OFF unless safety circuit testing is to be continued.

3.2.6.5 Testing to Verify Receiving Mainstage OK Signal After Engine Start. Prepare for test (Paragraph 3.2.6.1).

a. Position MS OK PRESS SW NO. 1 to OPEN.

Operation	Result
b. Momentarily press ENGINE START button on ENGINE CONTROL panel.	The engine goes into a normal start sequence and continues into mainstage. MAINSTAGE OK light comes on.
c. Momentarily press CUTOFF button on ENGINE CONTROL panel after MAINSTAGE OK light on ENGINE TEST/MONITOR panel comes on.	Engine cutoff occurs.

Operation	Result
d. Press CUTOFF RESET button on ENGINE CONTROL panel.	(1) CUTOFF LOCK-IN light goes off.
	(2) CUTOFF light on GROUND RELAY panel goes off.

e. Position MS OK PRESS SW NO. 1 to CLOSED.

f. Position MS OK PRESS SW NO. 2 on SIMULATOR panel to OPEN.

g. Repeat steps b through d.

h. Position MS OK PRESS SW NO. 2 on SIMULATOR panel to CLOSED.

i. Position ENGINE GROUND POWER switch on ENGINE CONTROL panel to OFF unless safety circuit testing is to be continued.

3.2.6.6 Testing for Failure to Receive Mainstage OK Signal After Engine Start. Prepare for test (paragraph 3.2.6.1).

a. Position MS OK PRESS SW NO. 1 and MS OK PRESS SW NO. 2 on SIMULATOR panel to OPEN.

b. Momentarily press ENGINE START button on ENGINE CONTROL panel.	After the 4 spark lights on ENGINE TEST/MONITOR panel go off, cutoff occurs.
c. Press CUTOFF RESET button on ENGINE CONTROL panel.	(1) CUTOFF LOCK-IN light goes off.
	(2) CUTOFF light on GROUND RELAY panel goes off.

d. Position MS OK PRESS SW NO. 1 and MS OK PRESS SW NO. 2 on SIMULATOR panel to CLOSED.

e. Position ENGINE GROUND POWER switch on ENGINE CONTROL panel to OFF.

3.2.6.7 Securing After Test. If another test is to be performed at this time, removal of test equipment required for that test may be disregarded.

a. Pull out all circuit breakers on electrical checkout console.

b. Position all console switches to off, neutral, or deenergized position.

c. Disconnect electrical cable NA5-27093TP261, and install the following engine electrical plugs, as applicable; then safety-wire with Inconel lockwire MS20995N: (Connect engine electrical connectors and install lockwire in accordance with R-3825-3.)

(1) Start tank pressure switch plug P16.

(2) Ignition detector probe plug P19.

(3) Mainstage OK pressure switch No. 1 plug P20.

(4) Fuel injector temperature transducer plug P22.

(5) Mainstage OK pressure switch No. 2 plug P26.

d. Secure electrical checkout console (paragraph 3.2.30.2).

3.2.7 TESTING AUGMENTED AND GAS GENERATOR SPARK IGNITERS. This test consists of energizing spark igniters and checking for sparks at ASI chamber and GG. Disregard all lights not specified in the procedure. Refer to section II for spark igniter system requirements before performing this test.

3.2.7.1 Preparing for Test.

a. Connect Electrical Checkout Console G1037 (figure 3-1).

b. Make sure that all spark igniter cables are connected.

c. Prepare Electrical Checkout Console G1037 (paragraph 3.2.1.2).

Operation	Result
d. Position switches on engine SIMULATOR panel of electrical checkout console as follows:	
(1) PREVALVE switch to CLOSED.	
(2) FACILITY READY to READY.	FACILITY READY light on ENGINE CONTROL panel comes on.

e. Position TEST/FIRE SELECT switch on GROUND RELAY panel of electrical checkout console to OK TO TEST.

f. Position test selector switch on ENGINE TEST/MONITOR panel of electrical checkout console to COMPONENT TEST.

Operation	Result
g. Position ENGINE GROUND POWER switch on ENGINE CONTROL panel of electrical checkout console to ON.	(1) The following lights on ENGINE TEST/MONITOR panel come on:
	(a) COMPONENT TEST.
	(b) IGNITION BUS ARMED.
	(c) On engines incorporating ECA 502670-111 or -211, START TANK PRESSURIZED and START TANK DEPRESSURIZED.
	(2) The following lights on ENGINE CONTROL panel come on:
	(a) ENGINE GROUND POWER.
	(b) MAINSTAGE OK NO. 1 DEPRESSURIZED.

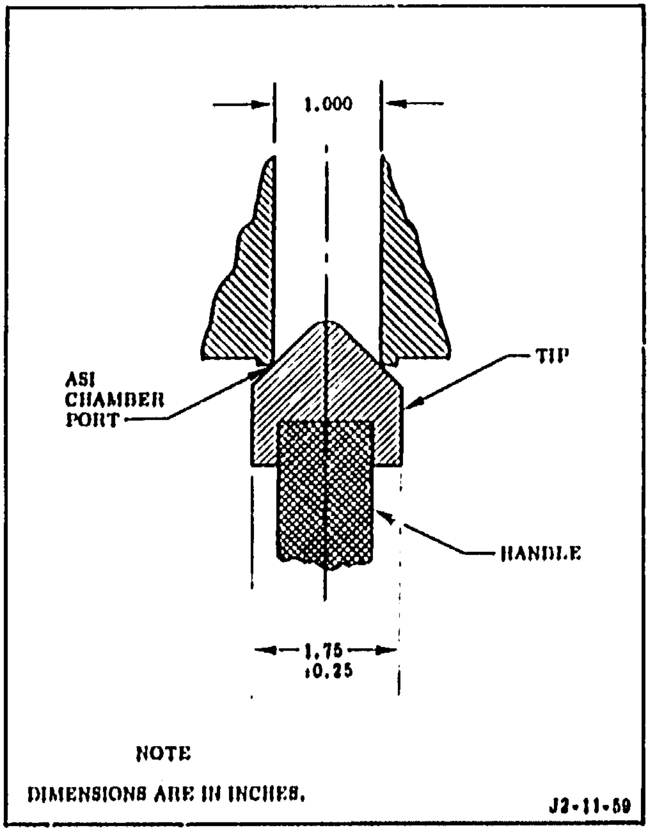


Figure 3-5. Augmented Spark Igniter Chamber Blocking Device (Typical)

Operation	Result
	(c) MAINSTAGE OK NO. 2 DEPRESSURIZED.
	(d) TEST.
	(e) ENGINE READY.

h. If a blocking device that meets the requirements of step i has been fabricated and is available, disregard step i.

i. Fabricate an ASI chamber blocking device that meets the following requirements: (Figure 3-5 illustrates a typical blocking device.)

(1) Handle of blocking device must be a wood, plastic, or metal rod long enough to reach through thrust chamber throat to ASI chamber port.

(2) Sound-muffling portion of blocking device must be a rubber or soft plastic, conical or spherical tip secured to rod. Tip diameter (if a sphere) or base width (if a cone) should be 1-1/2 to 2 inches.

3.2.7.2 Function Testing. When audibly testing GG spark igniter operation, insert ASI chamber blocking device through thrust chamber throat and hold tip against ASI chamber port. Tip of blocking device must not be forced into port.

Operation	Result
a. Position SPARK CONTROL switch on ENGINE TEST/MONITOR panel to NO. 1 ASI-NO. 1 GG.	NO. 1 GG SPARK and NO. 1 ASI SPARK lights come on.
b. Using a stethoscope, listen for an audible indication of No. 1 GG spark igniter operation.	Audible indication must be detected.
c. Visually observe operation of No. 1 ASI spark igniter through thrust chamber exit.	Operation must be verified.
d. Position SPARK CONTROL switch to NO. 2 ASI-NO. 2 GG.	NO. 2 GG SPARK and NO. 2 ASI SPARK lights come on.
e. Using a stethoscope, listen for an audible indication of NO. 2 GG spark igniter operation.	Audible indication must be detected.
f. Visually observe operation of NO. 2 ASI spark igniter through thrust chamber exit.	Operation must be verified.

g. Return SPARK CONTROL switch to OFF.

h. Position switches as follows:

(1) Test selector on ENGINE TEST/MONITOR panel to OFF.

(2) TEST/FIRE SELECT on GROUND RELAY panel to OFF.

(3) ENGINE GROUND POWER on ENGINE CONTROL panel to OFF.

(4) FACILITY READY on engine SIMULATOR panel to NOT READY.

3.2.7.3 Securing After Test. If another test is to be performed at this time, removal of test equipment required for that test may be disregarded. Secure electrical checkout console (paragraph 3.2.30.2).

3.2.8 TESTING MAINSTAGE OK PRESSURE SWITCHES. This test consists of pressure-actuation testing of mainstage OK pressure switches and recording pickup and dropout pressures. Disregard all lights not specified in the procedure. The following test equipment is required:

a. Electrical Checkout Console G1037.

b. Pneumatic Checkout Console G3100.

c. Data Recorder Console G3121.

d. Test adaptor 9025406 (test adaptor kit 9025405).

3.2.8.1 Preparing for Test.

a. Connect engine and all checkout equipment (figure 3-1).

b. Prepare Electrical Checkout Console G1037, Data Recorder Console G3121, and Pneumatic Checkout Console G3100 for use (paragraphs 3.2.1.2 through 3.2.1.4).

c. Remove cap from CALIPS CHECKOUT LINE customer connect on engine, and install test adaptor 9025406. Torque nut to 50-60 in-lb.

d. Connect a pressure hose between 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console and test adaptor installed on CALIPS CHECKOUT LINE customer connect.

Operation	Result
e. Position switches on engine SIMULATOR panel of electrical check-out console as follows:	
(1) PREVALVE switch to CLOSED.	
(2) FACILITY READY to READY.	FACILITY READY light on ENGINE CONTROL panel comes on.
f. Position TEST/FIRE SELECT switch on GROUND RELAY panel of electrical checkout console to OK TO TEST.	
g. Position TEST SELECTOR switch on ENGINE TEST/MONITOR panel of electrical checkout console to COMPONENT TEST.	
h. Position ENGINE GROUND POWER switch on ENGINE CONTROL panel of electrical checkout console to ON.	(1) The following lights on ENGINE TEST/MONITOR panel come on: (a) COMPONENT TEST. (b) IGNITION BUS ARMED. (c) On engines incorporating ECA 502670-111 or -211, START TANK PRESSURIZED and START TANK DEPRESSURIZED. (2) The following lights on ENGINE CONTROL panel come on: (a) ENGINE GROUND POWER. (b) MAINSTAGE OK NO. 1 DEPRESSURIZED. (c) MAINSTAGE OK NO. 2 DEPRESSURIZED. (d) TEST. (e) ENGINE READY.

i. Adjust facility pneumatic pressure to pneumatic checkout console to 1,000 psig minimum.

3.2.8.2 Actuation Testing.

a. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-1000).

b. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until REG SUPPLY PRESSURE gage indicates 225-250 psi.

Operation	Result
c. Leak-test line from CALIPS CHECK-OUT LINE customer connect to pressure switches on thrust chamber, and leak-test pressure switches.	Leakage is not allowable.

WARNING

Failure to observe safety requirements in step d can result in injury to personnel.

d. During remainder of this test, have all personnel stand behind adequate safety barriers or at a safe distance from engine while system is pressurized to 600 psig.

e. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until REG SUPPLY PRESSURE gage indicates 600 ±25 psi, and return to zero.

Operation	Result
f. Slowly turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE (do not exceed 600 psig) until event recorder pen 30 picks up and recorder pen 32 drops out. Record pressure as mainstage OK pressure switch No. 1 actuation pressure.	(1) MAINSTAGE OK NO. 1 PRESSURIZED light comes on and MAINSTAGE OK NO. 1 DEPRESSURIZED light goes off on ENGINE CONTROL panel. (2) REG SUPPLY PRESSURE gage must indicate 500 ±30 psi.
g. Slowly turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to DECREASE until event recorder pen 32 picks up and pen 30 drops out. Record pressure as mainstage OK pressure switch No. 1 deactuation pressure.	(1) MAINSTAGE OK NO. 1 DEPRESSURIZED light comes on and MAINSTAGE OK NO. 1 PRESSURIZED light goes off on ENGINE CONTROL panel. (2) REG SUPPLY PRESSURE gage must indicate 20-105 psi below actual actuation pressure recorded in step f.

h. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

i. Repeat steps f through h.

j. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until REG SUPPLY PRESSURE gage indicates 600 ±25 psi, and return to zero.

Operation	Result
k. Slowly turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE (do not exceed 600 psig) until event recorder pen 31 picks up and recorder pen 33 drops out. Record pressure as mainstage OK pressure switch NO. 2 actuation pressure.	(1) MAINSTAGE OK NO. 2 PRESSURIZED light comes on and MAINSTAGE OK NO. 2 DEPRESSURIZED light goes off on ENGINE CONTROL panel. (2) REG SUPPLY PRESSURE gage must indicate 500 ±30 psi.
l. Slowly turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to DECREASE until event recorder pen 33 picks up and recorder pen 31 drops out. Record pressure as mainstage OK pressure switch NO. 2 deactuation pressure.	(1) MAINSTA[illegible] light [illegible] MAINSTA[illegible] CONT[illegible] panel. (2) REG [illegible] gage must indicate [illegible] psi below actual [illegible] pressure [illegible] step [illegible]

m. Turn PRESSURE REG[illegible] MATIC SUPPLY PANEL (0-1000) [illegible] clockwise until REG SUPPLY [illegible] gage indicates zero.

n. Repeat steps [illegible] through [illegible]

o. On electrical checkout [illegible] switches as follows

(1) TEST SELECTOR [illegible] MONITOR panel to OFF

(2) TEST/FIRE SELECT [illegible] LAY panel to OFF.

(3) ENGINE GROUND POWER [illegible] CONTROL panel to OFF

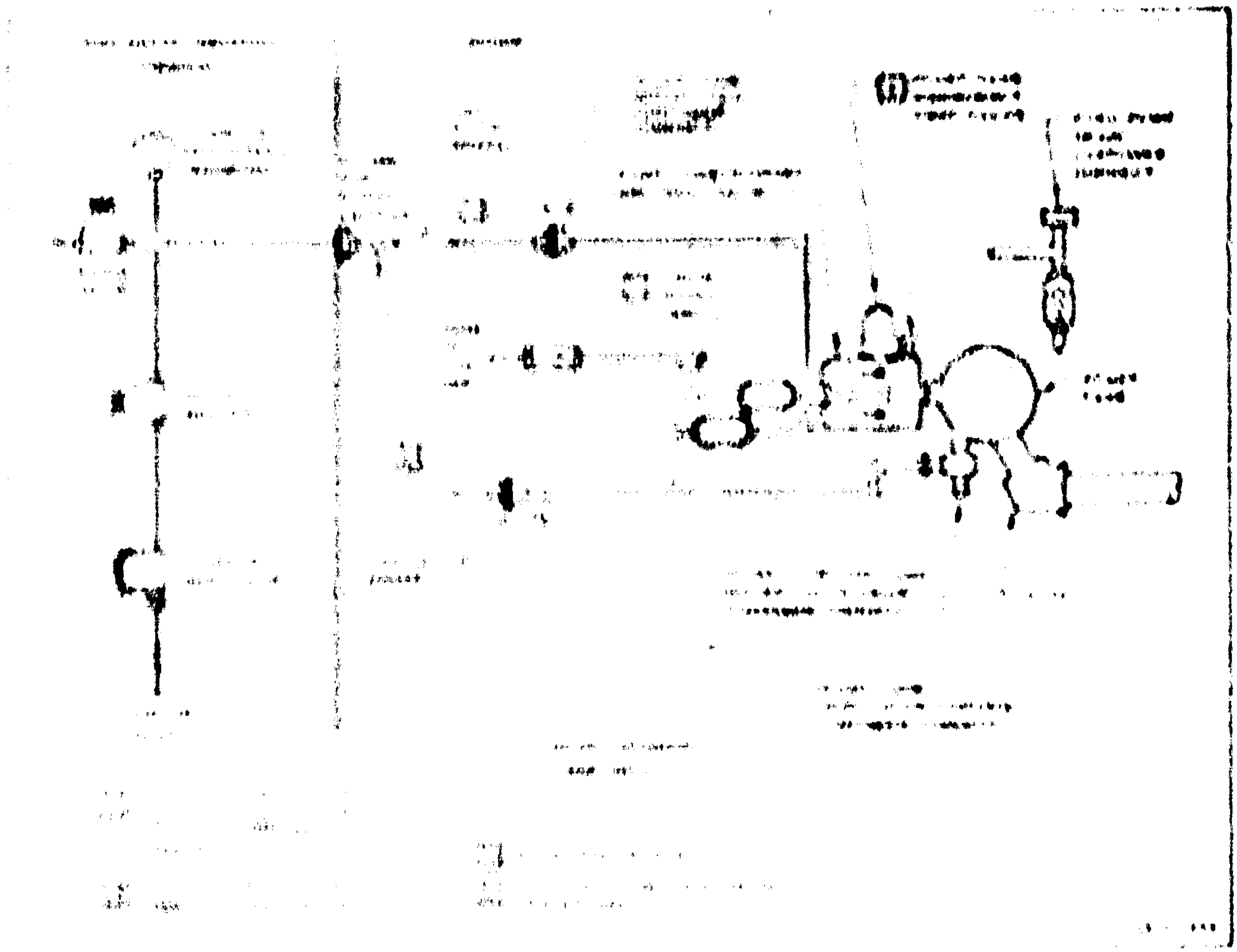
(4) FACILITY READY on engine [illegible] TOR panel to NOT READY

3.2.8.3 Securing After Test. If [illegible] to be performed at this time, [illegible] equipment required for that test [illegible] regarded.

a. Disconnect pneumatic [illegible] PSI SUPPLY OUTLET of pneumatic [illegible] console and test adapter [illegible]

b. Remove test adapter from [illegible] OUT LINE customer [illegible]

c. Reinstall protective cap [illegible] this test.



c. Prepare Pneumatic Flow Tester G3104 and Pneumatic Checkout Console G3106 (paragraphs 3.2.1.4 and 3.2.1.5).

d. Remove thrust chamber exit closure or open one desiccant access cover on closure.

e. Install test plate 9020274 on START TANK INITIAL FILL customer connect. Torque nuts to 61-75 in-lb.

f. Connect a pressure hose from 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console to test plate 9020274 installed on START TANK INITIAL FILL customer connect.

g. Install test plate 9020223 on START TANK VENT VALVE CONTROL customer connect. Torque nuts to 50-60 in-lb. Remove cap from test plate fitting.

h. Remove protective closure from START TANK VENT & RELIEF VALVE DRAIN customer connect.

i. On engines incorporating MD320 or MD351 change, remove cover from fuel pump drain line customer connect.

j. Adjust facility pneumatic supply to pneumatic checkout console to 600 psig minimum.

3.2.9.2 Leak Testing. See figure 3-7 for location of leak-test points.

a. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-1000).

b. On engines incorporating MD320 or MD351 change, perform steps c through h. On engines not incorporating MD320 or MD351 change, proceed to step i.

c. Slowly turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until REG SUPPLY PRESSURE gage indicates 100-150 psi.

d. Close REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-1000).

Operation	Result
e. Position EMERG START TANK VENT switch on ENGINE CONTROL PANEL to ON.	Light comes on, and pressure in start tank vents to zero.
f. Position EMERG START TANK VENT switch on ENGINE CONTROL PANEL to OFF.	Light goes off.

g. Open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-1000).

h. Install cover on fuel pump drain line customer connect.

i. Slowly turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until REG SUPPLY PRESSURE gage indicates 500 ±100 psi.

j. Record time when step i was performed.

Operation	Result
k. Using pneumatic flowtester or leak-test compound, as applicable, leak-test lines and connections listed in figure 3-7.	Leakage is not allowable.

NOTE

When leak-testing valve-to-tank joints, personnel must follow the general leak-test procedures. Insulation must not be leak tested at valve flanges. Gas coming from under the insulation cover may be caused from compression of entrapped air between the tank and insulation and not from a defective tank. The tank itself is leak-tested by the mass-loss leakage method.

Operation	Result
l. Using leak detector, leak-test braided sections of system under test.	Leakage is not allowable.

3.2.9.3 Testing Start System Mass-Loss Leakage.

a. Wait one hour after recorded initial start tank pressurization time. (Refer to paragraph 3.2.9.2, step j.)

Leak-Test Point Description	Location Code in Figure 3-32	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
Start tank pressure port TF1	F1	X	
TF1 line to primary FI package			X
TF1 line to auxiliary FI package[(a)]			X
TF1 line from tee to static-test transducer			X
Start tank liquid refill line from check valve to start tank support-and-fill valve[(b)]			X
Start tank liquid refill line from tee in TF1 instrumentation line to capped end of refill line[(c)]			X
Start tank support-and-fill valve connection to start tank	F2	X	
Start tank vent-and-relief valve connection to start tank	F3	X	
Start tank temperature transducer TFT1	F4	X	
STDV connection to start tank	F5	X	
Start tank emergency vent valve connection to start tank support-and-fill valve[(d)]	F52	X	
Blank plate on start tank support-and-fill valve[(e)]	F52	X	

(a) Engines incorporating MD269, MD282, MD296, MD313, or MD315 change.
(b) Engines incorporating MD331 or MD344 change but not incorporating MD347 change.
(c) Engines not incorporating MD331 or MD344 change or engines incorporating MD347 change.
(d) Engines incorporating MD320 or MD351 change.
(e) Engines not incorporating MD320 or MD351 change.

Figure 3-7. Start System Leak-Test Points

Operation	Result
b. Observe REG SUPPLY PRESSURE gage on PNEUMATIC SUPPLY PANEL (0-1000). If pressure is not within limits, adjust PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) until pressure gage indicates 500 ±10 psi.	Pressure must be 500 ±10 psig.

NOTE

A printout may be obtained by momentarily turning the POWER switch on the DIGITAL VOLT-OHMMETER to PRINT.

Operation	Result
c. Press TEMPERATURE SELECT switch and CHANNEL NO. 9 button on flight instrumentation checkout console. Record DIGITAL VOLT-OHMMETER indication.	Temperature must be 120° F (5.107 volts) or less.

d. If temperature is not within allowable limits, allow a cooling or stabilization period; then repeat steps b and c until all conditions have been met.

NOTE

Steps e and f remove supply pressure to start tank system.

Operation	Result
e. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) fully counterclockwise.	REG SUPPLY PRESSURE gage indicates zero.

f. Close REG SUPPLY SHUTOFF VALVE, and open BLEED valve. Maintain BLEED valve open during mass-loss test.

NOTE

To select PRESSURE SELECT when TEMPERATURE SELECT is actuated, the SPEED AND FLOW SELECT button must be pressed twice to deactuate TEMPERATURE SELECT.

g. Press PRESSURE SELECT switch and CHANNEL NO. 6 button on flight instrumentation checkout console. Record DIGITAL VOLT-OHMMETER indication.

h. Press TEMPERATURE SELECT switch and CHANNEL NO. 9 button on flight instrumentation checkout console. Record DIGITAL VOLT-OHMMETER indication.

i. Record time that readings in steps g and h were obtained. Determine mass (M) using the following formula:

$$M = \frac{5.2533\ PV}{TV + 1.222}$$

where

M = mass (pounds)
PV = pressure indication (volts)
TV = temperature indication (volts)

j. Wait one hour, then obtain and record DIGITAL VOLT-OHMMETER values for pressure and temperature. Determine mass using formula in step i.

NOTE

If mass loss slightly exceeds the specified value, three more consecutive tests may be performed and the average mass loss for the four tests computed. The system is acceptable if the average mass loss does not exceed the specified value.

- If net mass gain is obtained (up to 0.001 pound per hour), start tank mass leakage must be recorded as zero.

Operation	Result
k. Subtract value obtained in step j from value obtained in step i. Record as start tank mass-loss leakage.	Maximum allowable loss in mass is 0.0066 pound (in one hour).

NOTE

Steps l through p vent start tank system pressure.

l. Disconnect test hose connected between 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate fitting of test plate 0020274.

m. Connect test hose disconnected in step l to test plate 9020223 installed on START TANK VENT VALVE CONTROL customer connect.

n. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-1000).

WARNING

Failure to observe the safety requirements of step o can result in injury to personnel.

Operation	Result
o. Clear all personnel from area of START TANK VENT & RELIEF VALVE DRAIN customer connect; then slowly turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until REG SUPPLY PRESSURE gage indicates 250 psi maximum.	Start tank pressure must vent from START TANK VENT & RELIEF VALVE DRAIN customer connect.
p. Leak-test start tank vent valve control line.	Leakage is not allowable.
q. Using leak detector, leak-test braided sections of system under test.	Leakage is not allowable.

r. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

3.2.9.4 Securing After Test. If another test is to be performed, removal of test equipment required for that test may be disregarded.

a. Disconnect all pressure hoses from pneumatic checkout console and engine.

b. Remove the following test plates, and reinstall applicable protective closures on customer connects:

(1) START TANK VENT VALVE CONTROL customer connect.

(2) START TANK INITIAL FILL customer connect.

c. Secure flight instrumentation checkout console, pneumatic checkout console, and pneumatic flowtester (paragraphs 3.2.30.1, 3.2.30.4, and 3.2.30.5).

3.2.10 TORQUE-TESTING OXIDIZER TURBOPUMP.

a. If hydraulic pump is not installed on accessory drive pad, carefully remove plug and seal from drive pad cover plate.

b. If hydraulic pump is installed on accessory drive pad, carefully remove torque access cover plate and plate seal from turbine exhaust hood.

c. Attach torque wrench to adapter, insert adapter into opening, and engage splines of turbine shaft and adapter. If torquing through accessory drive pad, use adapter from wrench kit 9016712-11. If torquing through torque access plate opening, use adapter from wrench kit 9017259. Refer to R-3825-3 for torque adapter conversion information.

CAUTION

A torque in excess of 1,000 in-lb can damage the turbopump.

Operation	Result
d. Rotate turbine wheel clockwise (viewed from aft end of engine), and record maximum torque required to initiate rotation as breakaway torque.	(1) Maximum allowable breakaway torque is 1,000 in-lb. (2) On engines designated for SII stage, maximum allowable breakaway torque is 500 in-lb if hydraulic pump is installed. If torque exceeds limit, disconnect hydraulic pump and repeat test using 1,000 in-lb limit.

NOTE

When measuring torque with the hydraulic pump installed, indicated torque must be converted to actual torque due to the effect of the torque wrench adaptor.

Operation	Result
e. Continue rotating turbine slowly, and record torque required to maintain rotation as running torque.	Maximum allowable running torque is 200 in-lb.

f. Remove torque wrench and adapter from turbopump.

g. If torque access cover plate was removed, carefully install plate and seal. Torque plate mounting bolts to 40-50 in-lb.

h. If accessory drive pad cover plug was removed, carefully install plug and seal. Torque plug to 405-445 in-lb.

3.2.11 TORQUE-TESTING FUEL TURBOPUMP.

a. Remove plug and seal from fuel turbine torque access.

b. On engines not incorporating MD172 change, attach a torque wrench to adapter 0019801-11 from wrench kit 0016711-11, insert adaptor through torque access, and engage splines of turbine shaft and adapter.

c. On engines incorporating MD172 change, attach a torque wrench to adaptor 19-0025816 from wrench kit 0016711-21, insert adaptor through torque access, and engage hex on turbine wheel.

CAUTION

A torque in excess of 1,000 in-lb can damage the turbopump.

Operation	Result
d. Rotate turbine wheel counterclockwise (viewed from aft end of engine), and record maximum torque required to initiate rotation as breakaway torque.	Maximum allowable breakaway torque is 1,000 in-lb.
e. Continue rotating turbine shaft slowly, and record torque required to maintain rotation as running torque.	Maximum allowable running torque is 300 in-lb.

f. Remove wrench and adapter, and install plug and seal on torque access opening. Torque plug to 405-445 in-lb.

3.2.12 REVERSE-LEAK-TESTING OXIDIZER TURBOPUMP INTERMEDIATE SEAL PURGE CHECK VALVE. This test consists of applying pressure downstream of purge check valve and measuring reverse-flow leakage. Refer to section II for checkout constraints before performing this test.

a. The following test equipment is required:

(1) Pneumatic Checkout Console G3106.

(2) Test adapter 0024523 (kit 0024496).

(3) Coupling AN910-4J.

(4) Reducer AN919-6J.

(5) Nipple AN816-4-4J.

(6) Fitting PG4-312-A-N (Conax).

(7) Reducer AN912-5J.

b. Obtain adapter 0024523, and remove reducer AN919-14C and hose from adapter.

c. Install reducer AN919-6J with O-ring MS28778-6 in tee of adapter 0024523.

d. Assemble coupling AN910-4J, reducer AN912-5J, fitting PG4-312-A-N, and nipple AN816-4-4J.

e. Remove protective cap from adapter 0024523, and connect a pressure hose from adaptor to FLOWMETER OUTLET of pneumatic checkout console.

f. Remove cover from oxidizer turbopump intermediate seal purge check valve vent line.

g. Connect a pressure hose from adapter 0024523 to nipple; then install fitting on outlet of oxidizer turbopump intermediate seal purge check valve. Secure end of hose assembly at drain line.

h. Install a pressure cap on 0-100 PSI SUPPLY OUTLET of PNEUMATIC SUPPLY PANEL (0-100).

i. Prepare Pneumatic Checkout Console G3106. (Refer to paragraph 3.2.1.4.)

j. Adjust facility pneumatic pressure to checkout console to 40 psig minimum.

k. Close FLOWMETER NO. 1 SHUTOFF, FLOWMETER NO. 2 SHUTOFF, FLOWMETER BYPASS VALVE, and flowmeter BLEED VALVE.

l. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

m. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±1 psi.

Operation	Result
n. Slowly open FLOWMETER NO. 1 SHUTOFF. Observe flowmeter indication. Record leakage as oxidizer turbopump intermediate seal purge check valve reverse leakage.	Maximum allowable leakage is 25 scim.

o. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

p. Disconnect test hoses from penumatic checkout console and engine.

q. Reinstall cover on purge check valve vent line.

r. Remove reducer from adaptor, and reinstall reducer AN919-14C with O-ring MS28778-6. Reinstall protective cap on adaptor.

s. Retain fittings AN919-4J, AN919-6J, AN816-4-4J, AN912-5J, and PG4-312-A-N for testing of next engine.

t. Secure pneumatic checkout console. (Refer to paragraph 3.2.30.4.)

3.2.13 TESTING OXIDIZER FEED SYSTEM. This test consists of pressurizing and leak-testing the oxidizer feed system, then measuring the pump seal and pump shaft seal leakage. See figure 3-8 for oxidizer feed system test setup. Refer to section II for checkout constraints before performing this test. The following test equipment is required:

a. Electrical Checkout Console G1037.

b. Pneumatic Flow Tester G3104.

c. Pneumatic Checkout Console G3106.

d. Wrench adapter 9019875-11 (wrench kit 9016712-11).

e. Test plate 9019858 (kit 9016713).

eA. Test plate 9020222-11 (kit 9018843-11).

f. Test plate 9019961 (accumulator hose plate kit 9019960).

g. Test plate 9020275 (kit 9017274).

h. Test plate 9020526 (kit 9018840).

i. Test plate 9025399 (kit 9025400-11, 3 required).

j. Vent adaptor 9025423 (vent adaptor kit 9025424).

jA. Test adaptor 9025817.

jB. Test plate 9022534 (bleed valve adaptor set 9022447-11).

k. Exhaust system test plates and equipment:

(1) Test plate 9019860-11 (kit 9016710-11).

(2) Test plate 9020251-11 (kit 9016723-11).

(3) Adaptor 9022823 (kit 9018840).

(4) Test plate 9025399 (kit 9025400-11).

(5) Heat exchanger handler 9016790-11.

(6) Bypass valve removal tool 9020260.

(7) Duct flange brackets 9021015 and 9021016.

(8) Test plate 9020235 (kit 9016701-11).

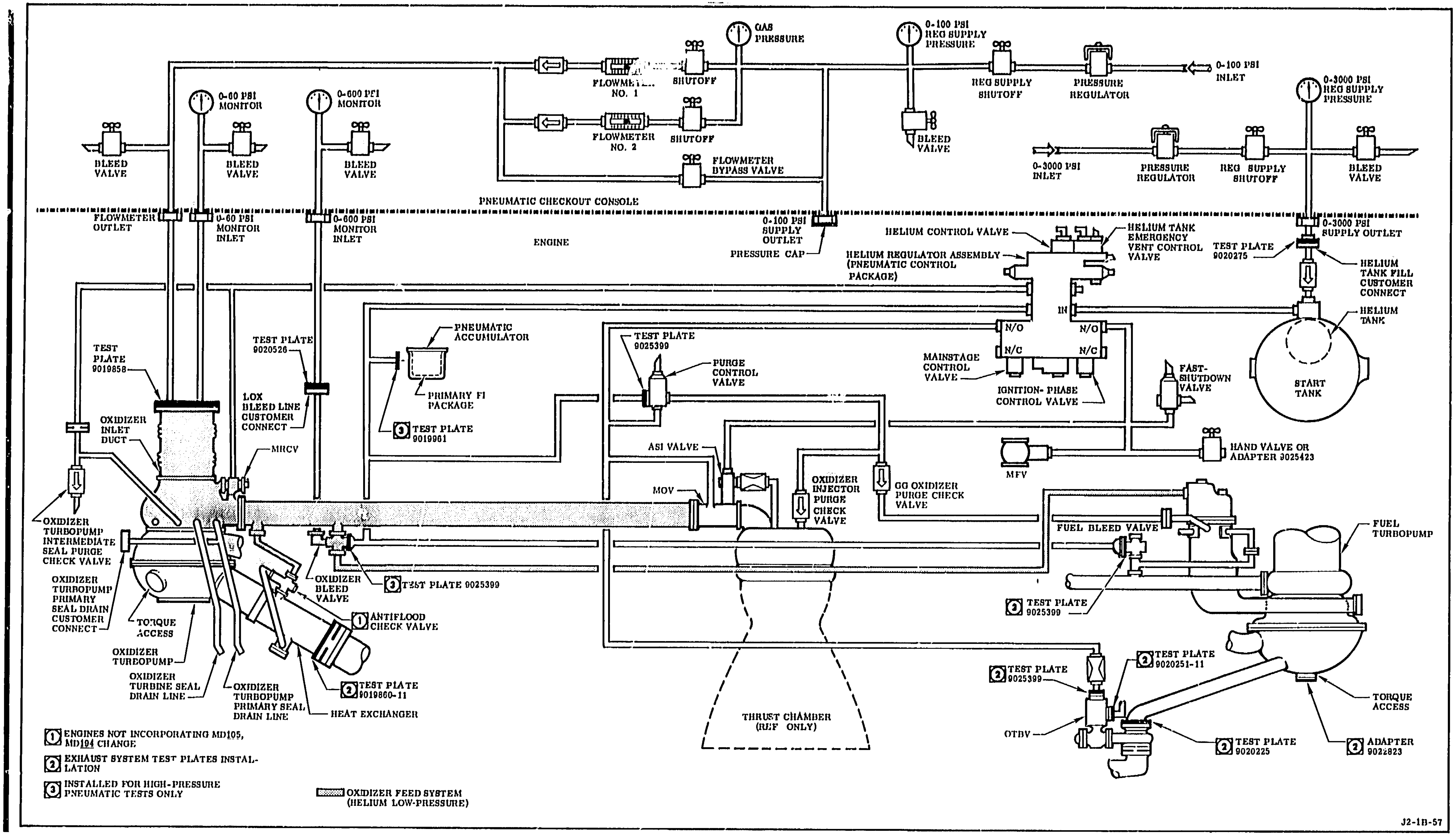


Figure 3-8. Oxidizer Feed System Test Setup

3.2.13.1 Preparing for Test.

a. Prepare Electrical Checkout Console G1037, Pneumatic Checkout Console G3106, and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.2, 3.2.1.4, and 3.2.1.5).

b. Remove closure from oxidizer turbopump turbine seal drain line.

c. Remove closure from primary seal drain line and install test adapter 9025817 or plug AN806S16. If plug is used, torque to 290-300 in-lb.

d. Remove closure from OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect and install test plate 9020222-11. Torque nuts to 61-75 in-lb. Remove cap from test plate port.

e. Remove cover from intermediate seal purge check valve vent line.

CAUTION

Bolts specified in step f must be used, to prevent galling of duct threaded inserts.

f. Using bolts RD111-1010-3616 (new bolts or bolts recoated with dry-film lubricant), install test plate 9019858 on oxidizer turbopump inlet duct. Torque bolts to 190-210 in-lb. Connect pressure hoses from test plate to FLOWMETER OUTLET and 0-60 PSI MONITOR INLET on pneumatic checkout console.

g. Install test plate 9020526 on LOX BLEED LINE customer connect. Torque nuts to 61-75 in-lb. Connect pressure hoses from test plate to 0-600 PSI MONITOR INLET of pneumatic checkout console.

h. Install test plate 9020275 on HELIUM TANK FILL customer connect. Torque nuts to 61-75 in-lb. Connect pressure hose from test plate to 0-3000 PSI SUPPLY OUTLET of pneumatic checkout console.

i. Make sure 0-100 PSI SUPPLY OUTLET on pneumatic checkout console is pressure capped.

j. Remove vent port relief valve from boss in MFV closing control line. Connect a hand valve or install vent adapter 9026423 in boss. Torque adapter to 40-60 in-lb. Close hand valve.

WARNING

Performing this test without disconnecting the hose from the pneumatic accumulator, and installing a test plate on the accumulator hose will result in exceeding the safe operating pressure of the pneumatic accumulator.

k. Disconnect pneumatic inlet hose and seal from accumulator (on primary FI package). Remove filter and seals.

l. Install protective closure on accumulator boss.

m. Install test plate 9019961 on accumulator hose. Torque bolts to 25-50 in-lb.

n. Install test plate 9025399 between line and inlet port of purge control valve. Torque bolts to 41-45 in-lb.

o. Install exhaust system test plates as outlined in paragraph 3.2.2.

3.2.13.2 Leak Testing. (See figure 3-9 for locations of leak-test points.)

a. Close BLEED valves on PNEUMATIC SUPPLY PANEL (0-100), FLOWMETER PANEL, PNEUMATIC MONITOR PANEL (0-60), and PNEUMATIC MONITOR PANEL (0-600).

b. Open FLOWMETER BYPASS valve on FLOWMETER PANEL.

c. Make sure that FLOWMETER NO. 1 and NO. 2 SHUTOFF valves on FLOWMETER PANEL are closed.

d. Open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

Leak-Test Point Description	Location Code in Figure 3-32	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
Oxidizer inlet duct connection to turbopump	L1	X	
PU valve outlet flange connection to turbopump[f]	L5	X	
MRCV outlet flange connection to turbopump[g]	L5	X	
PU valve outlet pressure instrumentation port PO9[f]	L6	X	
MRCV outlet pressure instrumentation port PO9[g]	L6	X	
PO9 line to auxiliary FI package			X
PU valve connection to PU valve actuator	L7	X	
MRCV pneumatic actuator housing to valve gate housing[g]	L7	X	
PU valve inlet flange connection to turbopump outlet manifold[f]	L8	X	
MRCV inlet flange connection to turbopump outlet manifold[g]	L8	X	
PU valve inlet pressure instrumentation port PO8[f]	L9	X	
MRCV inlet pressure instrumentation port PO8[g]	L9	X	
PO8 line to auxiliary FI package			X
Oxidizer turbopump connection to oxidizer high-pressure duct	L10	X	
Oxidizer turbopump discharge pressure instrumentation port PO2[a]	L11		X
PO2 line to static-test transducer[a]			X
Heat exchanger oxidizer supply line connection to oxidizer high-pressure duct	L12	X	
Oxidizer turbopump discharge pressure instrumentation port PO3	L13	X	
PO3 line to primary FI package			X
PO3 line from tee to static-test transducer[b]			X
Oxidizer flowmeter flange	L14	X	
Oxidizer turbopump discharge fluid-temperature transducer POT3	L15	X	

(a) Engines not incorporating MD237 change.
(b) Engines incorporating MD237 change.
(f) Engines not incorporating MD366 or MD371 change.
(g) Engines incorporating MD366 or MD371 change.

Figure 3-9. Oxidizer Feed System Leak-Test Points (Sheet 1 of 2)

Leak-Test Point Description	Location Code in Figure 3-32	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
Oxidizer bleed line connection to oxidizer bleed valve	L16	X	
Oxidizer bleed valve connection to oxidizer high-pressure duct	L17	X	
Oxidizer bleed valve - oxidizer temperature transducer GOT2	L18	X	
Oxidizer bleed valve capped port GO2[a]	L19	X	
Blank plate on oxidizer high-pressure duct	L20	X	
MOV upstream flange	L21	X	
Oxidizer ASI valve flange connection to MOV body	L22	X	
Heat exchanger oxidizer inlet pressure instrumentation port HO1[c]	L23	X	
HO1 line to auxiliary FI package[c]			X
GG oxidizer line connection to GG	L28	X	
Oxidizer turbopump bearing coolant pressure instrumentation line PO7 at weld bracket	L41		X
PO7 line to auxiliary FI package[d]			X
PO7 line from tee to static-test transducer[d]			X
PO7 line plug[e]			X

(a) Engines not incorporating MD237 change.
(c) Engines not incorporating MD105 or MD104 change.
(d) Engines not incorporating MD269, MD282, MD296, MD313, or MD315 change.
(e) Engines incorporating MD269, MD282, MD296, MD313, or MD315 change.

Figure 3-9. Oxidizer Feed System Leak-Test Points (Sheet 2 of 2)

Operation	Result
e. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until monitor gage on PNEUMATIC MONITOR PANEL (0-60) indicates 30 ±1 psi.	Monitor gage on PNEUMATIC MONITOR PANEL (0-600) also indicates 30 ±1 psi.
f. Using pneumatic flowtester or leak-test compound, as applicable, leak-test lines and connections listed in figure 3-9.	Leakage is not allowable.
g. Using leak detector, leak-test braided sections of system under test.	Leakage is not allowable.

3.2.13.3 Measuring Pump Seal and Pump Shaft Seal Leakages.

a. Slowly open FLOWMETER NO. 2 SHUTOFF valve; then close FLOWMETER BYPASS valve. If leakage is less than 50 sclm, open FLOWMETER NO. 1 SHUTOFF valve, then close FLOWMETER NO. 2 SHUTOFF valve.

b. Remove plug and seal from oxidizer turbine access (accessory drive pad cover plate).

c. Install a torque wrench to wrench adapter 9019875-11, insert through turbine access, and engage splines of turbine shaft and adapter.

CAUTION

A torque in excess of 1,000 in-lb can damage the turbopump.

d. Rotate turbine wheel clockwise (viewed from aft end of engine) a minimum of 5 complete revolutions to determine maximum leakage point. Use pneumatic flowtester to measure leakage from oxidizer pump seal drain line. (On engines incorporating MD301, MD302, MD322, or MD323 change, measure leakage at OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.) Continue to rotate turbine wheel to position where maximum leakage is noted; then record leakage indicated on flowtester.

e. Record system leakage indicated on pneumatic checkout console flowmeter.

f. Remove wrench and adapter; then reinstall plug and seal in turbine access of oxidizer turbine exhaust duct. Torque plug to 405-445 in-lb.

g. Using pneumatic flowtester, measure leakage from fitting of test adapter 9022823 installed on torque access of fuel turbine exhaust duct. Keep flowtester connected to adapter for a minimum of 10 minutes and until flowmeter stabilizes. Record leakage.

h. Close FLOWMETER NO. 1 or NO. 2 SHUTOFF valve, as applicable.

i. Open FLOWMETER BYPASS valve.

Operation	[illegible]
j. Position [illegible] VALVES switch to CLOSED and FACILITY READY switch to READY on engine SIMULATOR panel.	[illegible]
k. Position TEST [illegible] GROUND RELAY panel [illegible]	[illegible]
l. Position test [illegible] TEST MONITOR panel [illegible]	[illegible]
m. Position ENGINE GROUND POWER switch on ENGINE CONTROL panel to ON.	[illegible]
n. [illegible] PLY SHUTOFF [illegible] PANEL [illegible]	[illegible]

[illegible]

ag. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

Operation	Result
ah. Using hand valve or vent adapter 9025423 in boss in MFV closing control line, vent pressure from control system. After all pressure has vented, close hand valve.	Control system depressurizes.
ai. Position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	HELIUM CONTROL light goes off.
aj. Position FACILITY READY switch on SIMULATOR panel to NOT READY.	FACILITY READY light on ENGINE CONTROL panel goes off.
ak. Position the following switches on electrical checkout console to OFF:	All lights on console go off.
(1) Test selector on ENGINE TEST/MONITOR panel.	
(2) TEST/FIRE SELECT on GROUND RELAY panel.	
(3) ENGINE GROUND POWER on ENGINE CONTROL panel.	

al. Disconnect pressure hose from FLOWMETER OUTLET and test plate 9019858 installed on oxidizer turbopump inlet duct.

am. Connect a needle valve to FLOWMETER OUTLET. Close needle valve.

an. Make sure FLOWMETER NO. 1 and NO. 2 SHUTOFF valves on FLOWMETER PANEL are closed.

ao. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until monitor gage on PNEUMATIC SUPPLY PANEL (0-100) indicates 30 ±1 psi. Maintain 30 ±1 psig while performing steps ap through as.

ap. Connect pneumatic flowtester to outlet of needle valve; then adjust needle valve until flow indicated on flowtester is equal to leakage recorded in step g.

NOTE

FLOWMETER NO. 2 must be used if total flow exceeds 50 sclm.

Operation	Result
aq. Open FLOWMETER NO. 1 valve, and close FLOWMETER BYPASS valve. Allow pressure to stabilize; then record leakage indicated on FLOWMETER NO. 1. Record as oxidizer turbopump shaft seal and GG control valve oxidizer poppet combined leakage.	Maximum allowable leakage is 1.5 sclm.

ar. If leakage value exceeds 1.5 sclm, perform steps as through bj. If value is 1.5 sclm or less, proceed to step bk.

as. Close FLOWMETER NO. 1 or NO. 2 SHUTOFF valve, as applicable; then close needle valve.

at. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

au. Disconnect oxidizer bleed valve from high-pressure duct.

av. Install test plate 9022534 from bleed valve adapter set 9022447-11 (components adapter set 9016796) on oxidizer inlet flange of bleed valve. Torque bolts to 61-75 in-lb.

aw. Disconnect needle valve from FLOWMETER OUTLET, and connect pressure hose from FLOWMETER OUTLET to test plate 9022534.

ax. Connect pressure hose between LOX BLEED LINE customer connect and 0-600 PSI MONITOR INLET of pneumatic checkout console.

Operation	Result
ay. Open FLOWMETER BYPASS valve; then turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until monitor gage on PNEUMATIC SUPPLY PANEL (0-100) indicates 30 ±1 psi.	Monitor gage on PNEUMATIC MONITOR PANEL (0-600) also indicates 30 ±1 psi.

az. Slowly open FLOWMETER NO. 2 SHUTOFF valve; then close FLOWMETER BYPASS valve. If leakage is less than 50 scim, open FLOWMETER NO. 1 SHUTOFF valve, and then close FLOWMETER NO. 2 SHUTOFF valve.

ba. Allow pressure to stabilize; then record leakage indicated on FLOWMETER NO. 1 or FLOWMETER NO. 2. Record leakage as GG control valve oxidizer poppet leakage.	Maximum allowable leakage is 1.5 scim.
bb. Subtract leakage value obtained in step ba from leakage value obtained in step aq. If a negative result is obtained, record as zero. Record results as oxidizer turbopump shaft seal leakage.	Maximum allowable leakage is 20 scim.

bc. Close FLOWMETER NO. 1 or NO. 2 SHUTOFF valve, as applicable.

bd. Open FLOWMETER BYPASS valve.

be. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

bf. Disconnect pressure hose from FLOWMETER OUTLET and test plate on oxidizer bleed valve inlet flange; then remove test plate.

bg. Install oxidizer bleed valve on high-pressure duct, and cross-torque bolts to 143-157 in-lb and safetywire.

bh. Connect a needle valve to FLOWMETER OUTLET. Close needle valve. Connect pneumatic flowtester to outlet of needle valve.

bi. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until monitor gage on PNEUMATIC SUPPLY PANEL (0-100) indicates 30 ±1 psi.

bj. Slowly open FLOWMETER NO. 2 SHUTOFF valve; then close FLOWMETER BYPASS valve. Step bk may be disregarded if steps as through bj were performed.

bk. Open FLOWMETER NO. 2 SHUTOFF valve, and close FLOWMETER NO. 1 SHUTOFF valve.

Operation	Result
bl. Adjust needle valve until flow indicated on pneumatic flowtester is equal to leakage recorded in step d. Allow pressure to stabilize; then record leakage indicated on FLOWMETER NO. 2. Record as oxidizer turbopump primary seal leakage.	Maximum allowable leakage is 350 scim.

bm. Close FLOWMETER NO. 2 SHUTOFF valve.

bn. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

Operation	Result
bo. Subtract total leakage recorded in steps aq and bl from leakage recorded in step e; record as oxidizer system leakage. If a minus figure is obtained, record leakage rate as zero.	Maximum allowable leakage difference is 17 sclm.

bp. If leakage recorded in step bo exceeds specified limits, perform one additional test. If recorded leakages for second test are within specified limits, oxidizer feed system leakage is satisfactory. If a minus figure is obtained when total leakage rates are subtracted, record leakage rate as zero.

NOTE

Steps bq through bv are required only if the oxidizer bleed valve was disconnected.

bq. Disconnect needle valve from FLOWMETER OUTLET, and connect pressure hose from FLOWMETER OUTLET to fitting on test plate 9019858 on oxidizer turbopump inlet duct.

br. Open FLOWMETER BYPASS valve.

Operation	Result
bs. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until monitor gage on PNEUMATIC MONITOR PANEL (0-60) indicates 30 ±1 psi.	Monitor gage on PNEUMATIC MONITOR PANEL (0-600) also indicates 30 ±1 psi.
bt. Using pneumatic flowtester, leak-test the following connections and instrumentation taps: L16, L17, L18, and L19 on oxidizer bleed valve (See figure 3-9.)	Leakage is not allowable.

bu. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

bv. Disconnect pressure hose between LOX BLEED LINE customer connect and 0-600 PSI MONITOR INLET of pneumatic checkout console.

3.2.13.4 Securing After Test. If another test is to be performed, removal of test equipment required for that test may be disregarded.

a. Disconnect pressure hoses from pneumatic checkout console and from test plates on oxidizer turbopump inlet duct and HELIUM TANK FILL customer connect.

b. Remove test plates from LOX BLEED LINE and HELIUM TANK FILL customer connects.

c. Remove test plate from oxidizer turbopump inlet duct.

d. Remove hand valve or vent adapter from boss in MFV closing control line.

e. Reinstall vent port check valve in boss in MFV closing control line. (Refer to R-3825-3.)

f. Remove test adapter or plug from oxidizer turbopump primary seal drain line and remove test plate from OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.

g. Remove test plate installed between pneumatic accumulator inlet hose and flange. Install seals, filter, and pneumatic hose with bolts and washers. Torque bolts to 53-65 in-lb.

h. Remove test plate from oxidizer bleed valve control port. Install seal and connect control line to oxidizer bleed valve with bolts, washers, and bracket. Torque bolts to 41-45 in-lb.

i. Remove test plate from fuel bleed valve control port. Install seal and control line to fuel bleed valve with bolts, washers, and bracket. Torque bolts to 41-45 in-lb.

j. Remove exhaust system test plates as outlined in paragraph 3.2.3.

k. Reinstall protective closures removed for this test.

l. Secure electrical checkout console, pneumatic checkout console, and pneumatic flowtester (paragraphs 3.2.30.2, 3.2.30.4, and 3.2.30.5.)

3.2.14 TESTING FUEL FEED SYSTEM. This test consists of pressurizing and leak-testing the fuel feed system, then measuring the pump seal and pump shaft seal leakage. See figure 3-10 for fuel feed system test setup. When performing turbopump primary and secondary seal leak tests, refer to figure 3-11 for allowable conditional leakage limits. Refer to section II for checkout constraints before performing this test. The following test equipment is required:

a. Electrical Checkout Console G1037.

b. Pneumatic Flow Tester G3104.

c. Pneumatic Checkout Console G3106.

d. On engines incorporating MD172 change, wrench adapter 19-9025816 (wrench kit 9016711-21).

e. On engines not incorporating MD172 change, wrench adapter 9019861-11 (wrench kit 9016711-11).

f. Test plate 9019858 (kit 9016713).

g. Test plate 9020222-11 (kit 9018843-11).

h. Test plate 9020275 (kit 9017274).

i. Test plate 9020526 (kit 9018840).

j. Test plate 9025399 (kit 9025400-11).

k. Vent adapter 9025423 (vent adapter kit 9025424).

l. Exhaust system test plates and equipment:

(1) Test plate 9019860-11 (kit 9016710-11).

(2) Test plate 9020251-11 (kit 9016723-11).

(3) Adapter 9022823 (kit 9018846).

(4) Test plate 9025399 (kit 9025400-11).

(5) Heat exchanger handler 9016790-11.

(6) Bypass valve removal tool 9020269.

(7) Duct flange brackets 9021015 and 9021016.

(8) Test plate 9020225 (kit 9016701-11).

3.2.14.1 Preparing for Test.

a. Prepare Electrical Checkout Console G1037, Pneumatic Checkout Console G3106, and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.2, 3.2.1.4, and 3.2.1.5).

CAUTION

Bolts specified in step b must be used to prevent galling of duct threaded inserts.

b. Using bolts RD111-1010-3616 (new bolts or bolts recoated with dry-film lubricant), install test plate 9019858 on fuel turbopump inlet duct. Torque bolts to 190-210 in-lb. Connect pressure hoses from test plate to FLOWMETER OUTLET and 0-60 MONITOR INLET on pneumatic checkout console. Make sure that 0-100 PSI SUPPLY OUTLET on pneumatic checkout console is pressure-capped.

c. Install test plate 9020526 on FUEL BLEED LINE customer connect. Torque nuts to 61-75 in-lb. Connect pressure hose from test plate to 0-600 MONITOR INLET on pneumatic checkout console.

d. Install test plate 9020275 on HELIUM TANK FILL customer connect. Torque nuts to 61-75 in-lb. Connect pressure hose from test plate to 0-3000 PSI SUPPLY OUTLET on pneumatic checkout console.

e. Remove vent port check valve from boss in MFV closing control line. Connect a hand valve or vent adapter 9025423 in boss. Torque adapter to 40-65 in-lb. Close hand valve.

NOTE

The hand valve or adapter is used to eliminate flow of helium to prevent depletion of facility helium supply.

f. Remove protective cover from oxidizer turbine seal drain line.

g. Remove protective cover from oxidizer turbopump primary seal drain line (at thrust chamber exit), or on engines incorporating MD301, MD302, MD322, or MD323 change, remove cover from OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.

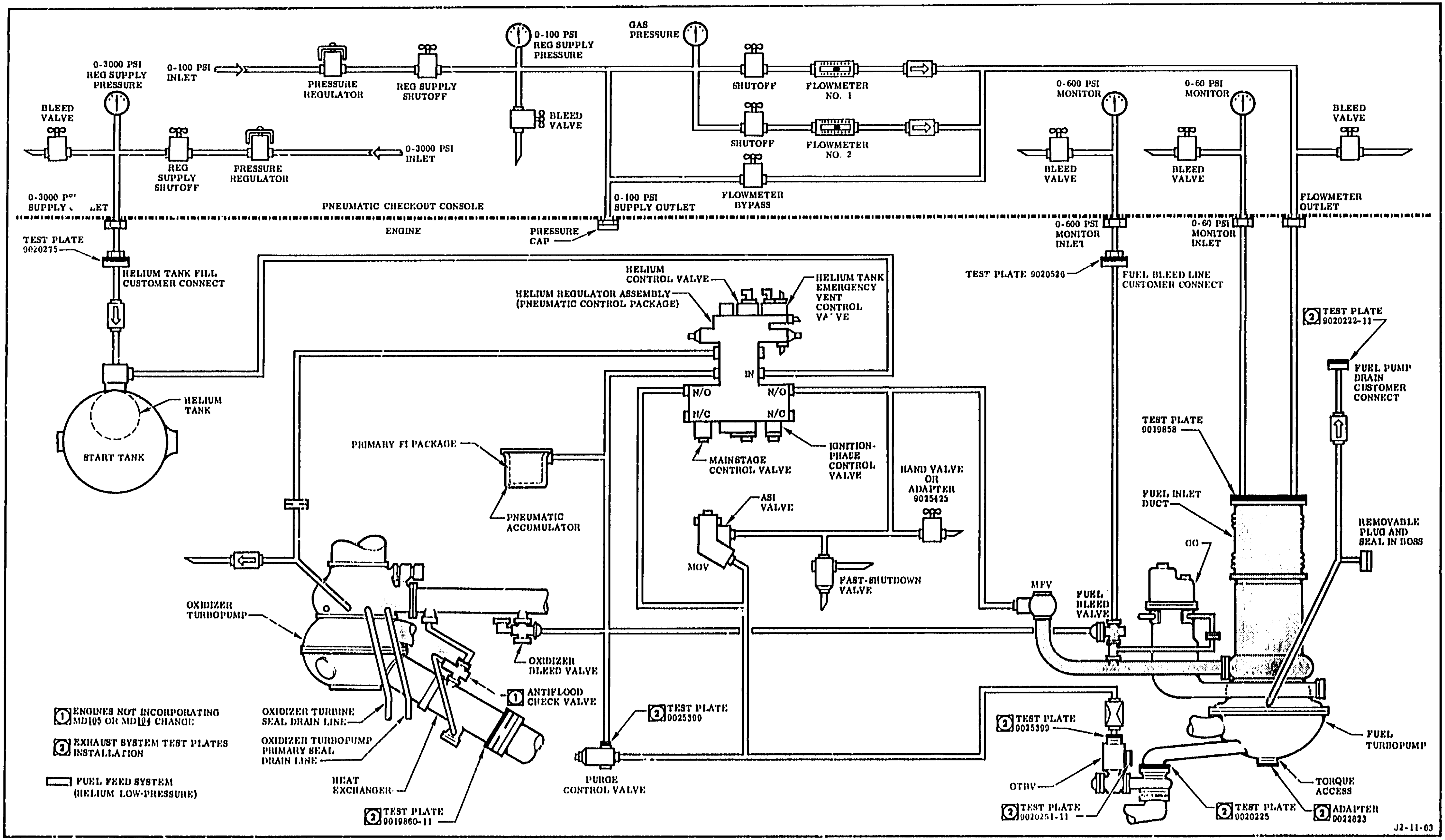


Figure 3-10. Fuel Feed System Test Setup

Secondary Seal Helium Leakage	Primary Seal Helium Leakage: 9 SCIM or Less	Primary Seal Helium Leakage: Greater Than 9 SCIM but Less Than or Equal to 350 SCIM	Primary Seal Helium Leakage: Greater Than 350 SCIM
75 SCIM or Less	Acceptable	Acceptable	Replace primary seal. (a)
Greater Than 75 SCIM but Less or Equal to 500 SCIM	Acceptable	Replace secondary seal. (a)	Replace primary and secondary seals. (a)
Greater Than 500 SCIM	Replace secondary seal. (a)	Replace secondary seal. (a)	Replace primary and secondary seals. (a)

(a) Refer to R-3825-3.

Figure 3-11. Allowable Fuel Turbopump Primary and Secondary Seal Leakages and Replacement Criteria

h. Disconnect pneumatic inlet line and seal from inlet port of purge control valve. Install test plate 0025309 from test plate kit 0025400-11 between line and valve inlet port. Torque bolts to 41-45 in-lb.

i. Install test plate 0020222-11 on FUEL PUMP DRAIN customer connect. Torque nuts to 61-75 in-lb.

j. Remove plug and seal from boss between fuel turbopump and fuel turbopump primary seal drain check valve.

k. Install exhaust system test plates as outlined in paragraph 3.2.2.

3.2.14.2 Leak Testing.

a. Close BLEED valves on PNEUMATIC SUPPLY PANEL (0-100), FLOWMETER PANEL, PNEUMATIC MONITOR PANEL (0-60), and PNEUMATIC MONITOR PANEL (0-600).

b. Open FLOWMETER BYPASS on FLOWMETER PANEL.

c. Make sure that FLOWMETER NO. 1 and NO. 2 SHUTOFF valves on FLOWMETER PANEL are closed.

d. Open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

Operation	Result
e. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until monitor gage on PNEUMATIC MONITOR PANEL (0-60) indicates 30 ±1 psi.	Monitor gage on PNEUMATIC MONITOR PANEL (0-600) also indicates 30 ±1 psi.
f. Using pneumatic flowtester or leak-test compound, as applicable, leak-test lines and connections listed in figure 3-12.	Leakage is not allowable.
g. Using leak detector, leak-test braided sections of system under test.	Leakage is not allowable.

Leak-Test Point Description	Location Code in Figure 3-32	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
MFV upstream flange	F6	X	
Fuel turbopump discharge fluid-temperature transducer PFT1	F7	X	
GG fuel line connection to GG	F8	X	
Fuel inlet duct connection to turbopump	F9	X	
Fuel turbopump interstage pressure instrumentation port PF6	F10	X	
PF6 line to transducer(a)			X
Fuel turbopump bearing temperature transducer PST1(b)	F11		X
Fuel turbopump connection to support (below pump volute)	F12	X	
Fuel turbopump discharge fluid-temperature transducer port PFT1a	F13	X	
Fuel turbopump to fuel high-pressure duct	F14	X	
Fuel turbopump discharge pressure instrumentation port PF2	F15		X
PF2 line to static-test transducer			X
Fuel bleed valve capped port GF5(c)	F16	X	
Fuel bleed valve temperature transducer GFT1	F17	X	
Fuel bleed line connection to fuel bleed valve	F18	X	
Fuel bleed valve connection to fuel bleed valve adapter	F19	X	
Fuel bleed valve adapter connection to fuel high-pressure duct	F20	X	
Fuel turbopump discharge pressure instrumentation port PF3	F21	X	
PF3 line to primary FI package			X
Fuel flowmeter flange	F22	X	

(a) Engines not incorporating MD233 change.
(b) Engines not incorporating MD172 change.
(c) Engines not incorporating MD237 change.

Figure 3-12. Fuel Feed System Leak-Test Points (Sheet 1 of 2)

Leak-Test Point Description	Location Code in Figure 3-32	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
Fuel turbopump balance piston cavity pressure instrumentation port PF5	F45		X
PF5 line to auxiliary FI package			X
PF5 line from tee to static-test transducer			X
Fuel turbine seal cavity purge line (TG10) at weld bracket	F46		X
Fuel turbopump balance piston sump pressure at capped line (PF4)	F47		X
Fuel turbopump primary seal purge line (PF7) at weld bracket	F48		X

Figure 3-12. Fuel Feed System Leak-Test Points (Sheet 2 of 2)

3.2.14.3 Measuring Turbopump Primary Seal and Pump Shaft Seal Leakages.

a. Slowly open FLOWMETER NO. 2 SHUTOFF valve; then close FLOWMETER BYPASS valve. If leakage is less than 50 scim, open FLOWMETER NO. 1 SHUTOFF valve; then close FLOWMETER NO. 2 SHUTOFF valve.

b. Remove adapter 9032823 from torque access of turbine exhaust duct.

c. On engines not incorporating MD172 change, install a torque wrench to wrench adaptor 9010861-11, insert through torque access, and engage splines of turbine shaft and adapter.

d. On engines incorporating MD172 change, install a torque wrench to wrench adapter 10-9025810, insert through torque access, and engage hex on turbine wheel.

CAUTION

A torque in excess of 1,000 in-lb can damage the turbopump.

e. Rotate turbine wheel counterclockwise (viewed from aft end of engine) a minimum of 5 complete revolutions to determine maximum leakage point. Use pneumatic flowtester to measure leakage from boss between fuel turbopump and fuel turbopump drain check valve. Continue to rotate turbine wheel to position where maximum leakage is noted; then record leakage indicated on flowtester.

f. Record system leakage indicated on pneumatic checkout console flowmeter.

g. Remove wrench and adapter; then reinstall adaptor 9022823 in torque access of fuel turbine exhaust duct. Torque adapter to 50-60 in-lb.

h. Using pneumatic flowtester, measure leakage from fitting of test adapter 9022823 installed on torque access of fuel turbine exhaust duct. Record leakage.

Operation	Result
i. Position switches on engine SIMULATOR panel of electrical checkout console as follows:	
(1) PREVALVES to CLOSED.	
(2) FACILITY READY to READY.	FACILITY READY light on ENGINE CONTROL panel comes on.

j. Position TEST/FIRE SELECT switch on GROUND RELAY panel to OK TO TEST.

k. Position test selector switch on ENGINE TEST/MONITOR panel to COMPONENT TEST.

Operation	Result
l. Turn ENGINE GROUND POWER switch on ENGINE CONTROL panel to ON.	(1) The following lights on ENGINE CONTROL panel come on: (a) ENGINE GROUND POWER. (b) MAINSTAGE OK NO. 1 DEPRESSURIZED. (c) MAINSTAGE OK NO. 2 DEPRESSURIZED. (d) TEST. (2) The following lights on ENGINE/TEST MONITOR panel come on: (a) COMPONENT TEST. (b) IGNITION BUS ARMED. (c) On engines incorporating ECA 502670-111 or -211, START TANK PRESSURIZED and START TANK DEPRESSURIZED.

m. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-3000).

Operation	Result
n. Position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to ON.	HELIUM CONTROL light comes on.

o. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) to INCREASE until REG SUPPLY PRESSURE gage indicates 225-250 psi.

Operation	Result
p. Open BLEED valve on PNEUMATIC MONITOR PANEL (0-600).	[illegible] gage on PNEUMATIC [illegible] PANEL [illegible]

q. Disconnect pressure line between [illegible] BLEED LINE customer [illegible] MONITOR INLET of [illegible]

Operation	Result
r. Using pneumatic flowtester, measure fuel bleed valve leakage at FUEL BLEED LINE customer connect. Record actual value as fuel bleed valve leakage.	Maximum [illegible] leakage is [illegible]

s. Open FLOWMETER BYPASS [illegible] FLOWMETER PANEL.

t. Close FLOWMETER NO. 1 or NO. 2 SHUTOFF valve, as applicable.

u. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) [illegible] clockwise until REG SUPPLY PRESSURE gage indicates zero.

v. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) [illegible] clockwise until REG SUPPLY PRESSURE gage indicates zero.

w. Using hand valve or vent adapter [illegible] in boss in MFV closing control line, vent pressure from control system. After all pressure has vented, close hand valve.

Operation	Result
x. Position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	HELIUM CONTROL light goes off.
y. Position FACILITY READY switch on engine SIMULATOR panel to NOT READY.	FACILITY READY light on ENGINE CONTROL panel goes off.

[illegible]

Operation	Result
ap. Leak-test plug installed in fitting between fuel turbopump and turbopump primary seal drain check valve.	Leakage is not allowable.

aq. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

3.2.14.4 Securing After Test. If another test is to be performed, the removal of test equipment required for that test may be disregarded.

a. Disconnect pneumatic hoses from pneumatic checkout console and from test plates on fuel turbopump inlet duct and HELIUM TANK FILL customer connect.

b. Remove test plates from the following customer connects:

(1) FUEL BLEED LINE.

(2) HELIUM TANK FILL.

(3) FUEL PUMP DRAIN.

c. Remove test plate from fuel turbopump inlet duct.

d. Remove hand valve or vent adapter from boss in MFV closing control line.

e. Reinstall vent port check valve in boss in MFV closing control line. (Refer to R-3825-3.)

f. Remove exhaust system test plates as outlined in paragraph 3.2.3.

g. Reinstall protective closures removed for this test.

h. Secure electrical checkout console, pneumatic checkout console, and pneumatic flowtester (paragraphs 3.2.30.2, 3.2.30.4, and 3.2.30.5).

3.2.15 TESTING PURGE SYSTEM. This test consists of pressurizing the purge manifold, measuring the flow from each exit, and leak-testing the purge and drain lines. See figure 3-13 for purge system test setup. Refer to section II for checkout constraints before performing this test. The following test equipment is required:

a. Pneumatic Flow Tester G3104.

b. Pneumatic Checkout Console G3106.

c. On engines incorporating MD234 change, test plate 9025399 (kit 9025400-11).

d. Test plate 9020222-11 (kit 9018843-11).

e. Test adapter 9024523 (adapter kit 9024496).

f. Exhaust system test plates and equipment:

(1) Test plate 9019860-11 (kit 9016710-11).

(2) Test plate 9020251-11 (kit 9016723-11).

(3) Adapter 9022823 (kit 9018846).

(4) Test plate 9025399 (kit 9025400-11).

(5) Heat exchanger handler 9016790-11.

(6) Bypass valve removal tool 9020269.

(7) Duct flange brackets 9021015 and 9021016.

(8) Test plate 9020225 (kit 9016701-11).

3.2.15.1 Preparing For Test.

a. Prepare Pneumatic Checkout Console G3106 and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.4 and 3.2.1.5).

b. Remove protective closures from the following:

(1) Oxidizer turbine seal drain line.

(2) Fuel turbine seal drain line.

(3) Thrust chamber exit, or open one desiccant access opening on cover.

(4) FUEL PUMP DRAIN customer connect.

c. Remove plug and seal from fitting between fuel turbopump and fuel turbopump drain check valve.

d. On engines incorporating MD234 change, remove bolts and washers that secure drain line to start tank discharge valve, and remove seal.

e. Install test plate 9025399 from test plate kit 9025400-11 between drain line flange and start tank discharge valve drain line boss. Torque bolts to 41-45 in-lb.

f. Install test plate 9020222-11 on PURGE MANIFOLD SYSTEM customer connect. Torque nuts to 61-75 in-lb.

g. Install a tee fitting on test plate 9020222-11 installed on PURGE MANIFOLD SYSTEM customer connect.

h. Connect pneumatic hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console to tee on test plate.

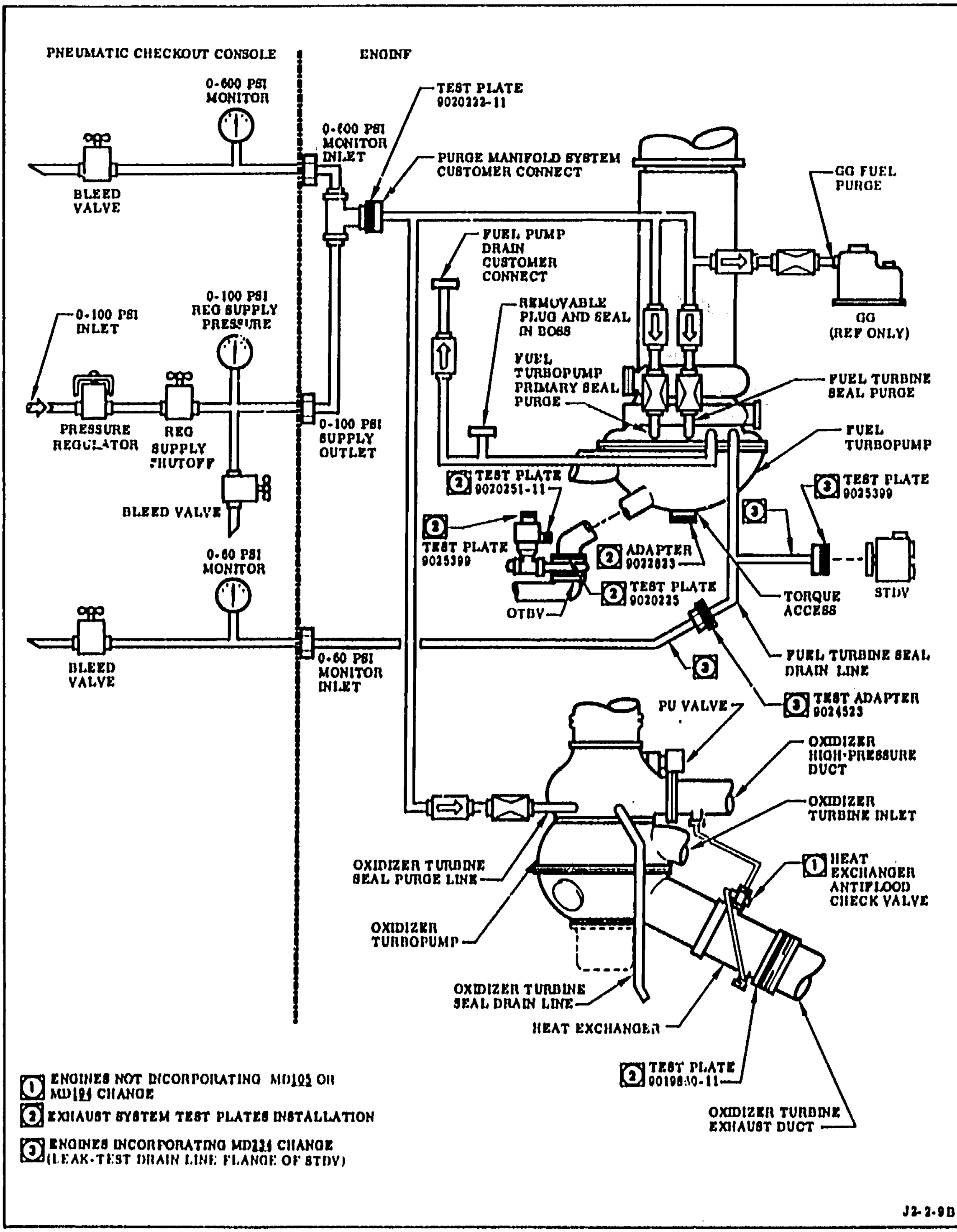


Figure 3-13. Purge System Test Setup

i. Connect pneumatic hose from 0-600 PSI MONITOR INLET of pneumatic checkout console to tee on test plate.

j. Install exhaust system test plates as outlined in paragraph 3.2.2.

k. Remove cap from adapter 9022823 installed on torque access of fuel turbine exhaust duct.

3.2.15.2 Flow Testing.

a. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

b. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until monitor gage on PNEUMATIC MONITOR PANEL (0-600) indicates 68 ±1 psi.

Operation	Result
c. Using pneumatic flowtester with accumulator, measure and record flow at each of the following points:	Total flowrates recorded in this step must not exceed 10,368 scim.
(1) Oxidizer turbine seal drain. Record actual value as oxidizer turbine seal purge flow.	Minimum allowable flow is 2,400 scim.
(2) Fuel turbine seal drain. Record actual value as fuel turbine seal purge flow.	Minimum allowable flow is 2,400 scim.
(3) Fitting between fuel turbopump and fuel turbopump drain check valve. Record actual value as fuel turbopump primary seal purge flow.	Minimum allowable flow is 200 scim.
(4) Fitting of test adapter 9022823 installed on torque access of fuel turbopump turbine exhaust duct. Record actual flow as GG fuel purge flow.	Minimum allowable flow is 2,400 scim.

3.2.15.3 Leak Testing.

Operation	Result
a. Using leak-test compound, leak-test the 4 purge lines from customer connect to the following:	Leakage is not allowable.
(1) Oxidizer turbopump.	
(2) Fuel turbopump (2 lines).	
(3) GG (fuel).	

b. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

c. Reinstall plug and seal in fitting between fuel turbopump and fuel turbopump drain check valve. Torque plug to 65-70 in-lb.

d. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±5 psi.

Operation	Result
e. Leak-test fitting between fuel turbopump and turbopump drain check valve.	Leakage is not allowable.
f. Using leak detector, leak-test braided sections of system under test.	Leakage is not allowable.

g. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

h. On engines incorporating MD234 change, perform steps i through p. On engines not incorporating MD234 change, proceed to paragraph 3.2.15.4.

i. Remove bolts and washers that secure drain line and test plate to valve. Remove test plate. Install seal and connect drain line to start tank discharge valve with bolts and washers. Torque bolts to 42-45 in-lb and safetywire.

j. Install cap on fitting of test adapter 9022823 installed on torque access of fuel turbine exhaust duct.

k. Install test adapter 9024523 on exit end of fuel turbine seal drain line (at thrust chamber exit). Torque hose clamp to 12-15 in-lb.

l. Connect pneumatic hose from 0-60 PSI MONITOR INLET of pneumatic checkout console to adapter 9024523 on fuel turbine seal drain line.

m. Close BLEED valve on PNEUMATIC MONITOR PANEL (0-60).

n. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until pressure gage on PNEUMATIC MONITOR PANEL (0-60) indicates 30 ±1 psi.

Operation	Result
o. Leak-test drain line flange at start tank discharge valve.	Leakage is not allowable.

p. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

3.2.15.4 Securing After Test.

a. Disconnect pneumatic hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console and test plate 0020222-11.

b. Disconnect pneumatic hose from 0-600 PSI MONITOR INLET of pneumatic checkout console and test plate 0020222-11.

c. On engines incorporating MD234 change, disconnect pneumatic hose from 0-60 PSI MONITOR INLET of pneumatic checkout console and test adapter 9024523.

d. On engines incorporating MD234 change, remove test adaptor 9024523 from exit end of fuel turbine seal drain line and install protective closure on line.

e. Remove test plate from PURGE MANIFOLD SYSTEM customer connect. Reinstall protective closure on customer connect.

f. Remove exhaust system test plates as outlined in paragraph 3.2.3.

g. Reinstall all protective closures removed for this test.

h. Secure pneumatic checkout console and pneumatic flowtester (paragraph 3.2.30.4 and 3.2.30.5).

3.2.16 REVERSE-FLOW-TESTING FUEL TURBINE SEAL PURGE CHECK VALVE. This test consists of applying pressure to the fuel turbine seal drain line to check reverse flow through the fuel turbine seal purge check valve and to leak-test the drain line. Refer to section II for checkout constraints before performing this test. See figure 3-14 for test setup.

a. The following test equipment is required:

(1) Pneumatic Flow Tester G3104.

(2) Pneumatic Checkout Console G3106.

(3) Test plate 0020222-11 (kit 0018843-11).

(4) Test adaptor 9024523 (adaptor kit 9024496).

(5) On engines incorporating MD234 change, test plate 9025309 (kit 9025400-11).

b. On engines incorporating MD234 change, remove bolts and washers that secure drain line to STDV, and remove seal. Install test plate 9025309 from test plate kit 9025400-11 between drain line flange and STDV drain line boss. Torque bolts to 41-45 in-lb.

c. Install test adaptor 9024523 on exit end of fuel turbine seal drain line. Torque hose clamp to 12-15 in-lb.

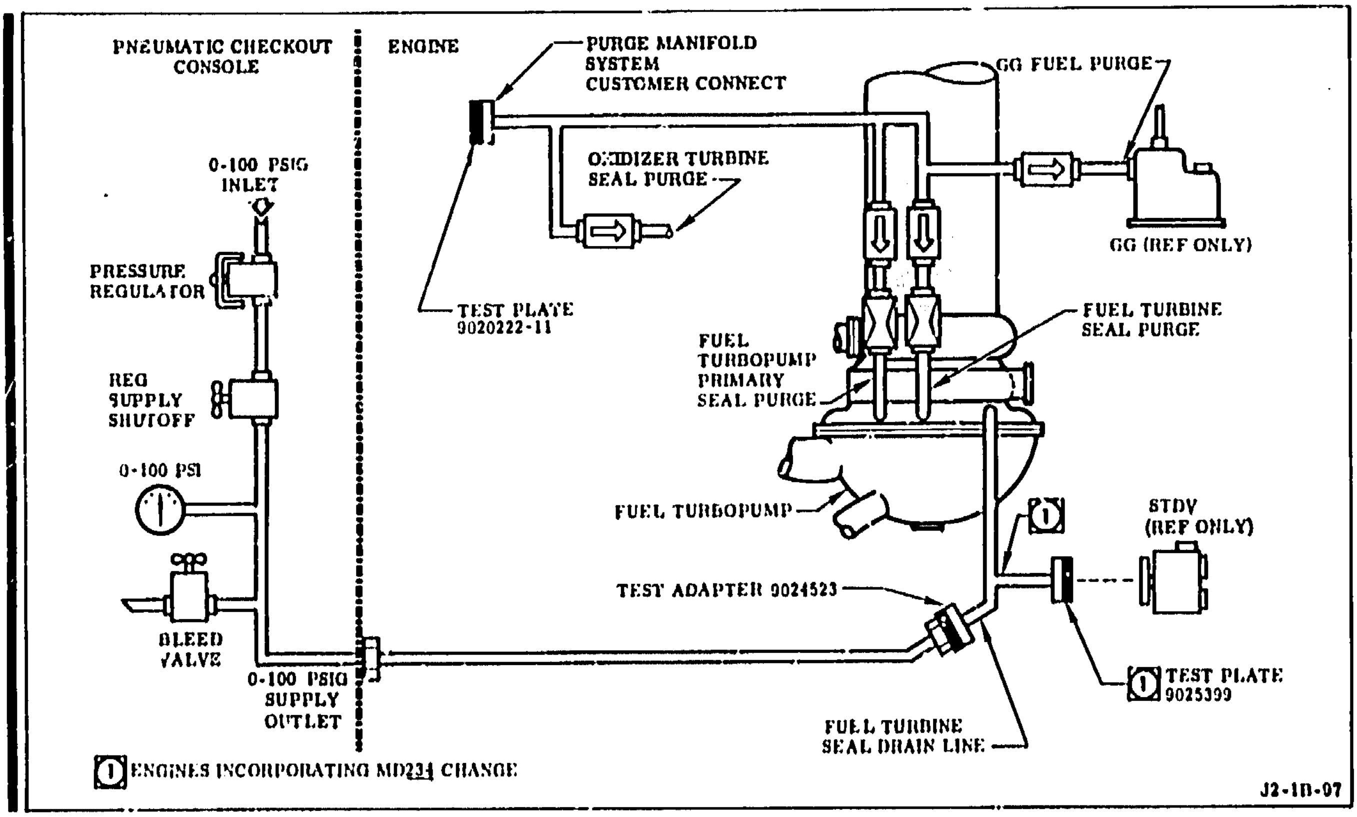


Figure 3-14. Fuel Turbine Seal Purge Check Valve Reverse-Flow Test Setup

d. Install test plate 9020222-11 on PURGE MANIFOLD SYSTEM customer connect. Remove cap from plate.

e. Prepare Pneumatic Checkout Console G3106 and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.4 and 3.2.1.5).

f. Connect a pressure hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console to adapter at exit end of fuel turbine seal drain line.

g. Adjust facility pneumatic supply to pneumatic checkout console to 100 psig minimum.

h. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

i. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±1 psi.

Operation	Result
j. Using pneumatic flowtester, measure leakage at PURGE MANIFOLD SYSTEM customer connect. Record as fuel turbine seal purge check valve reverse leakage.	Maximum allowable leakage is 100 scim.

NOTE

If the exhaust system test plates are installed and the GG and exhaust system is not vented to atmosphere, this value is actually a combination of the fuel turbine seal purge check valve reverse leakage and the GG fuel purge check valve reverse leakage. If the measured leakage is less than 100 scim, both check valves are acceptable. If the measured leakage is more than 100 scim, leakage must be isolated during GG and exhaust system test (paragraph 3.2.26).

Operation	Result
k. Leak-test fuel turbine seal drain line.	Leakage is not allowable.

l. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

m. Remove test hoses and test plates from engine and test equipment.

n. On engines incorporating MD234 change, remove bolts and washers that secure drain line and test plate to valve. Remove test plate. Install seal and connect drain line to STDV with bolts and washers. Torque bolts to 42-45 in-lb and safetywire.

o. Secure pneumatic checkout console and pneumatic flowtester (paragraphs 3.2.30.4 and 3.2.30.5).

3.2.17 REVERSE-FLOW-TESTING OXIDIZER TURBINE SEAL PURGE CHECK VALVE. This test consists of applying pressure to the oxidizer turbine seal drain line to measure reverse flow through the oxidizer turbine seal purge check valve and to leak-test the drain line. During this test, the oxidizer turbopump intermediate seal purge must be on. Refer to section II for checkout constraints before performing this test. See figure 3-15 for test setup.

a. The following test equipment is required:

(1) Pneumatic Checkout Console G3106.

(2) Electrical Checkout Console G1037.

(3) Pneumatic Flow Tester G3104.

(4) Test adapter 9024523 (adapter kit 9024496).

(5) Test plate 9020275 (kit 9017274).

(6) Test plate 9020222-11 (kit 9018843-11).

b. Install test adapter 9024523 on exit end of oxidizer turbine seal drain line. Torque hose clamp on adapter to 12-15 in-lb.

c. Install test plate 9020275 on HELIUM TANK FILL customer connect. Torque nuts to 61-75 in-lb.

d. Install test plate 9020222-11 on PURGE MANIFOLD SYSTEM customer connect. Torque nuts to 61-75 in-lb. Remove cap from plate.

e. Connect pressure hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console to adapter at exit end of oxidizer turbine seal drain line.

f. Connect pressure hose between 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate 9020275 on HELIUM TANK FILL customer connect.

g. Prepare Electrical Checkout Console G1037, Pneumatic Checkout Console G3106, and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.4, 3.2.1.2, and 3.2.1.5).

h. Adjust facility pneumatic supply to pneumatic checkout console to 500 psig minimum.

i. Remove protective closure from oxidizer turbopump intermediate seal purge check valve vent line exit.

j. Remove protective cover from oxidizer turbopump primary seal drain line (at thrust chamber exit), or on engines incorporating MD301, MD302, MD322, or MD323 change, remove cover from OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.

Operation	Result
k. Position PRE-VALVES switch to CLOSED and FACILITY READY switch to READY on engine SIMULATOR panel.	FACILITY READY light on ENGINE CONTROL panel comes on.

l. Position TEST/FIRE select switch on GROUND RELAY panel to OK TO TEST.

m. Position test selector switch on ENGINE TEST/MONITOR panel to COMPONENT TEST.

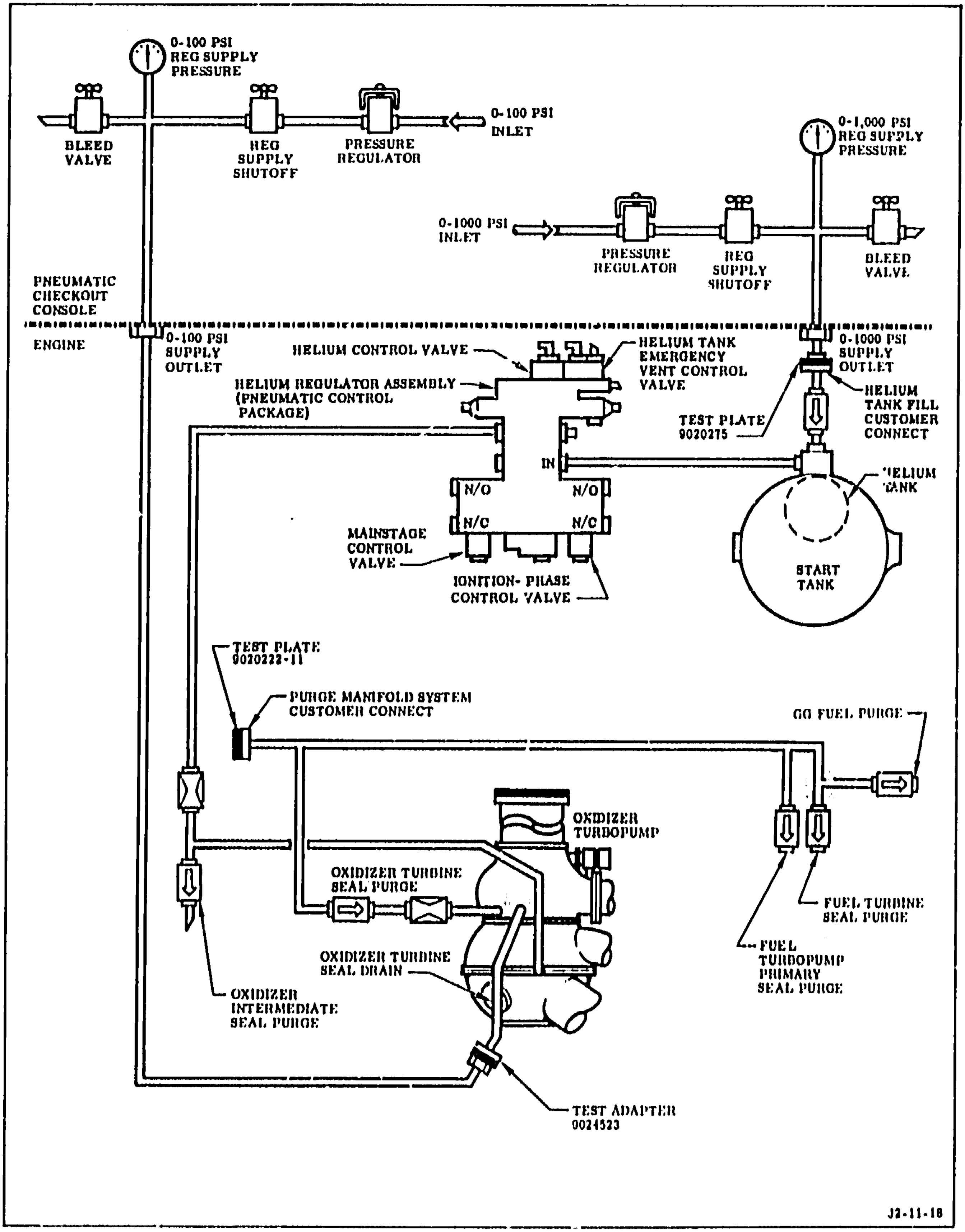


Figure 3-15. Oxidizer Turbine Seal Purge Check Valve Reverse-Flow Test Setup

Operation	Result
n. Turn ENGINE GROUND POWER switch on ENGINE CONTROL panel to ON.	(1) The following lights on ENGINE CONTROL panel come on:
	(a) ENGINE GROUND POWER.
	(b) MAINSTAGE OK NO. 1 DEPRESSURIZED.
	(c) MAINSTAGE OK NO. 2 DEPRESSURIZED.
	(d) TEST.
	(2) The following lights on ENGINE/TEST MONITOR panel come on:
	(a) COMPONENT TEST.
	(b) IGNITION BUS ARMED.
	(c) On engines incorporating ECA 502670-111, or -211, START TANK PRESSURIZED and START TANK DEPRESSURIZED.

o. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-1000).

Operation	Result
p. Position HELIUM CONTROL, IGNITION PHASE CONTROL, and MAINSTAGE CONTROL switches on ENGINE TEST/MONITOR panel to ON.	HELIUM CONTROL, IGNITION PHASE CONTROL, and MAINSTAGE CONTROL lights come on.

q. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until REG SUPPLY PRESSURE gage indicates 225-250 psi.

r. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

s. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±1 psi.

Operation	Result
t. Using pneumatic flowtester, measure flow at PURGE MANIFOLD SYSTEM customer connect. Record as oxidizer turbine seal purge check valve reverse leakage.	Maximum allowable leakage is 100 scim.
u. Leak-test oxidizer turbine seal drain line.	Leakage is not allowable.
v. Close REG SUPPLY SHUTOFF valve and open BLEED valve on PNEUMATIC SUPPLY PANEL (0-100).	Pressure vents, and REG SUPPLY PRESSURE gage indicates zero.
w. Position IGNITION PHASE CONTROL and MAINSTAGE CONTROL switches on ENGINE/TEST MONITOR panel to OFF.	IGNITION PHASE CONTROL and MAINSTAGE CONTROL lights go off.

x. Turn PRESSURE REGULATOR ON PNEUMATIC SUPPLY PANEL (0-1000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

Operation	Result
y. After all pressure has vented from pneumatic control system and helium tank, position HELIUM CONTROL switch on ENGINE/TEST MONITOR panel to OFF.	HELIUM CONTROL light goes off.

z. Remove test plate 9020222-11 from PURGE MANIFOLD SYSTEM customer connect. Reinstall cap on test plate.

aa. Disconnect pneumatic hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console and test adapter on oxidizer turbine seal drain line.

ab. Disconnect pneumatic hose from 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console and from test plate on HELIUM TANK FILL customer connect.

ac. Remove test plate from HELIUM TANK FILL customer connect.

ad. Remove test adapter from oxidizer turbine seal drain line.

ae. Reinstall all protective closures removed for this test.

af. Secure pneumatic checkout console, electrical checkout console, and pneumatic flowtester (paragraphs 3.2.30.4, 3.2.30.2, and 3.2.30.5).

3.2.18 LEAK-TESTING OXIDIZER TURBOPUMP PRIMARY SEAL DRAIN LINE. This test consists of applying pressure to the outlet end of the oxidizer turbopump primary seal drain line and leak-testing the line. During this test, the oxidizer turbopump intermediate seal purge must be on. Refer to section II for checkout constraints before performing this test. See figure 3-16 for test setup.

a. On engines incorporating MD166 (ECP J2-388) but not incorporating MD301, MD302, MD322, or MD323 change, disregard this test and perform leak test of oxidizer turbopump primary seal drain line and purge control valve vent line during thrust chamber test (paragraph 3.2.27).

b. The following test equipment is required:

(1) Pneumatic Checkout Console G3106.

(2) Electrical Checkout Console G1037.

(3) Pneumatic Flow Tester G3104.

(4) Test plate 9020222-11 (kit 9018843-11).

(5) Test plate 9019858 (kit 9016713).

(6) Test plate 9020275 (adapter kit 9017274)

c. Install test plate 9020275 on HELIUM TANK FILL customer connect. Torque nuts to 61-75 in-lb.

d. Connect a pressure hose between 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate installed on HELIUM TANK FILL customer connect.

e. Remove protective closure from oxidizer turbopump intermediate seal purge check valve vent line exit and oxidizer turbine seal drain line.

f. Prepare Pneumatic Checkout Console G3106, Electrical Checkout Console G1037, and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.4, 3.2.1.2 and 3.2.1.5).

CAUTION

Bolts specified in step g must be used to prevent galling of duct threaded inserts.

g. Using bolts RD111-1010-3616 (new bolts or bolts recoated with dry-film lubricant), install test plate 9019858 on oxidizer inlet duct. Torque bolts to 190-210 in-lb. Connect test hose from 0-60 PSI MONITOR INLET to test plate, and cap other test plate fitting. Close BLEED valve on PNEUMATIC MONITOR PANEL (0-60).

h. Install test plate 9020222-11 on OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect. Torque nuts to 61-75 in-lb. Connect pressure hose from test plate to 0-100 PSI SUPPLY OUTLET of pneumatic checkout console.

i. If burst diaphragm is installed on oxidizer turbopump primary seal drain line, remove burst diaphragm. (Refer to R-3825-3.) Install plug AN806S16 in nut in place of burst diaphragm on end of drain line.

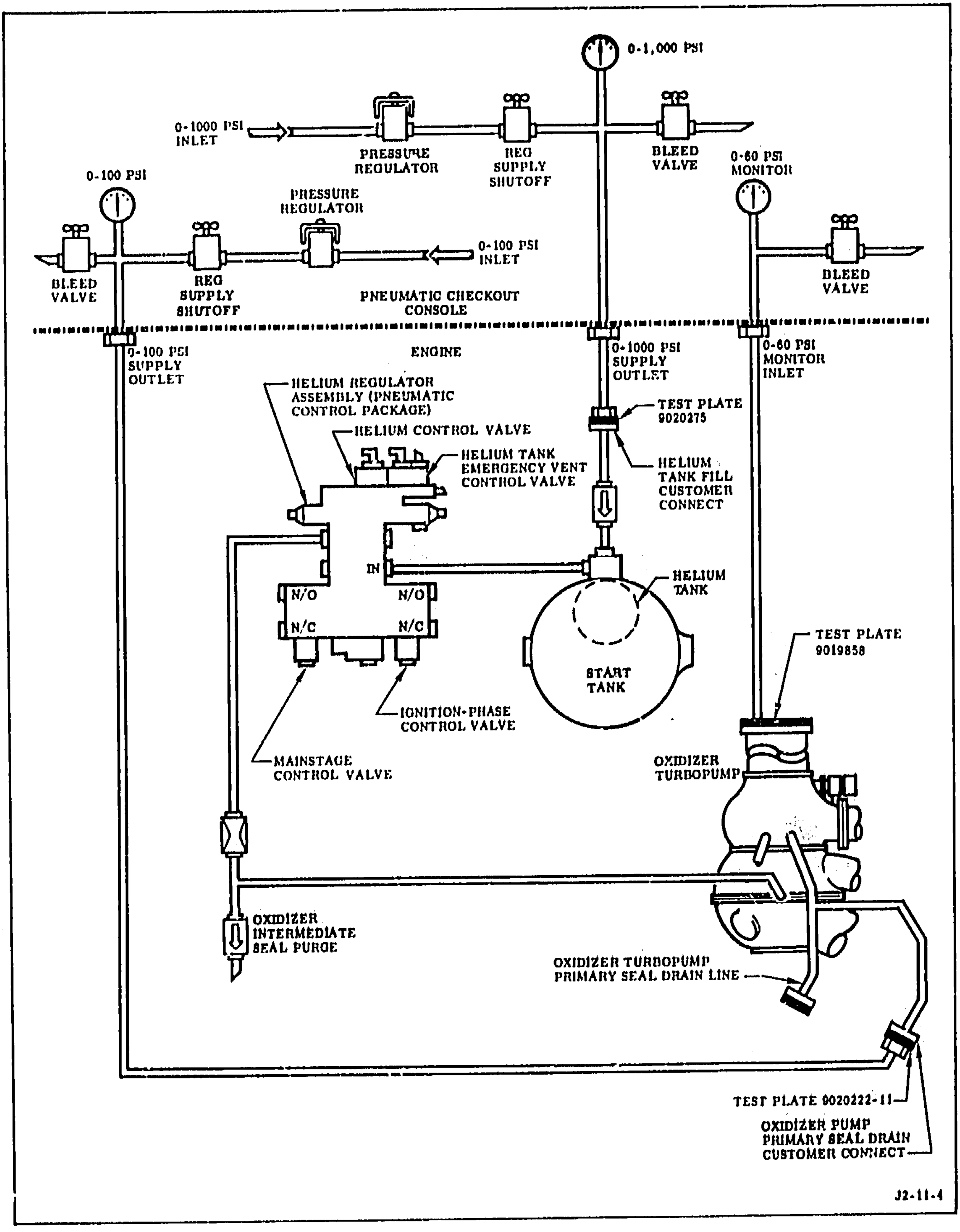


Figure 3-16. Oxidizer Turbopump Primary Seal Drain Line Leak Test Setup

j. Adjust facility pneumatic supply to pneumatic checkout console to 500 psig minimum.

k. Slip a plastic tube over oxidizer turbopump intermediate seal purge check valve vent line, and route tube to direct gas flow away from immediate engine area.

Operation	Result
l. Position HELIUM CONTROL, IGNITION PHASE CONTROL, and MAINSTAGE CONTROL switches on ENGINE TEST/MONITOR panel to ON.	HELIUM CONTROL, IGNITION PHASE CONTROL, and MAINSTAGE CONTROL lights come on.

m. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until REG SUPPLY PRESSURE gage indicates 225-250 psi.

n. Close BLEED valve and slowly open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100). Make sure that pressure remains at 30 ±1 psig.

o. Using leak-test compound, leak-test all joints and connections in oxidizer turbopump primary seal drain line including line from tee in drain line to customer connect.	Leakage is not allowable.
p. Using leak-test compound, leak-test connections of oxidizer turbopump primary seal pressure (PO6) instrumentation line from turbopump to auxiliary FI package and from tee to static-test transducer.	Leakage is not allowable.
q. Using leak detector, leak-test braided sections of OXIDIZER PUMP PRIMARY SEAL DRAIN customer-connect line.	Leakage is not allowable.

r. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

s. Open BLEED valve on PNEUMATIC MONITOR PANEL (0-60). Pressure gage indicates zero.

Operation	Result
t. Position IGNITION PHASE CONTROL and MAINSTAGE CONTROL switches on ENGINE TEST/MONITOR panel to OFF.	IGNITION PHASE CONTROL and MAINSTAGE CONTROL lights go off.

u. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

v. After all pressure has vented from pneumatic control system and helium tank, position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	HELIUM CONTROL light goes off.
w. Position the following switches on electrical checkout console to OFF:	All lights on electrical checkout console go off.

(1) Test selector on ENGINE TEST/MONITOR panel.

(2) TEST/FIRE SELECT on GROUND RELAY panel.

(3) ENGINE GROUND POWER on ENGINE CONTROL panel.

x. Position FACILITY READY switch on SIMULATOR panel to NOT READY.

y. Disconnect pressure hose from 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate installed on HELIUM TANK FILL customer connect.

z. Remove test plate from HELIUM TANK FILL customer connect.

aa. Remove test plate from OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.

ab. Remove plug AN806S16 if installed on end of overboard primary seal drain line. Reinstall burst diaphragm. (Refer to R-3825-3.)

ac. Remove test hose from test plate 9010868 on oxidizer inlet duct; then remove test plate.

ad. Remove plastic tube installed on intermediate seal purge check valve vent line exit.

ae. Reinstall protective closures removed for this test.

af. Secure electrical checkout console, pneumatic checkout console, and pneumatic flowtester (paragraphs 3.2.30.2, 3.2.30.4, and 3.2.30.5).

3.2.19 **REVERSE-FLOW-TESTING FUEL TURBOPUMP PRIMARY SEAL DRAIN CHECK VALVE.** This test consists of applying pressure to the fuel turbopump primary seal drain customer-connect line to measure reverse flow through the drain check valve and to leak-test the primary seal and start tank emergency vent valve (on engines incorporating MD320 or MD351 change) drain lines. Refer to section II for checkout constraints before performing this test. See figure 3-17 for test setup.

a. The following test equipment is required:

(1) Pneumatic Checkout Console G3106.

(2) Pneumatic Flow Tester G3104.

(3) Test plate 9020222-11 (kit 9018843-11).

b. Install test plate 9020222-11 on FUEL PUMP DRAIN customer connect. Torque nuts to 61-75 in-lb.

c. Prepare Pneumatic Checkout Console G3106 and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.4 and 3.2.1.5).

d. Adjust facility pneumatic supply to pneumatic checkout console to 100 psig.

e. Remove plug and seal from fitting between fuel turbopump and fuel turbopump primary seal drain check valve.

f. Connect pressure hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console to test plate at FUEL PUMP DRAIN customer connect.

g. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

h. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±1 psi.

Operation	Result
i. Using pneumatic flowtester, measure leakage from fitting between fuel turbopump and fuel turbopump primary seal drain check valve. Record actual value as fuel turbopump primary seal drain check valve reverse leakage.	Maximum allowable leakage is 25 scim.
j. Leak-test the drain line from check valve to customer connect.	Leakage is not allowable.
k. On engines incorporating MD320 or MD351 change, leak-test the line from fuel pump drain line to start tank emergency vent valve.	Leakage is not allowable.

l. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

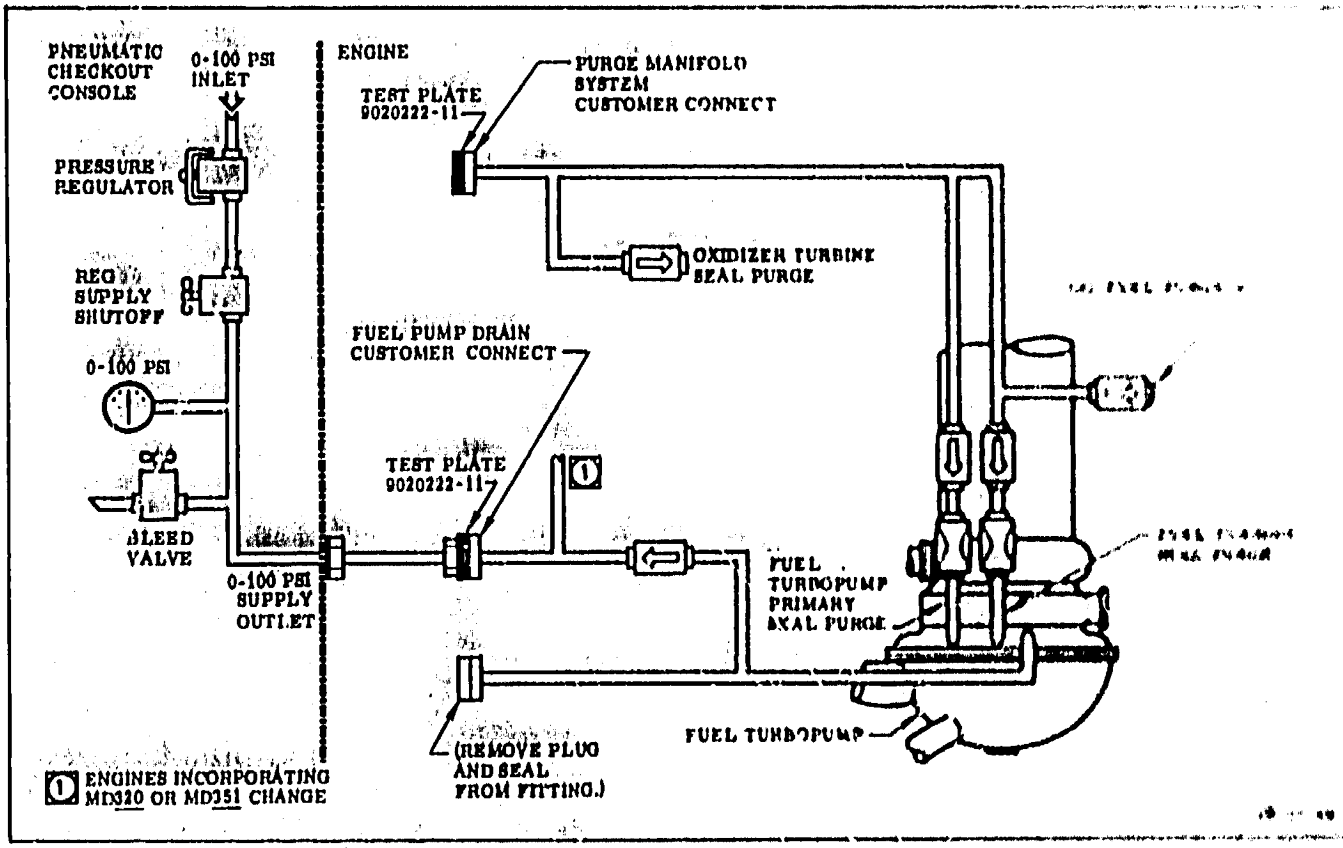


Figure 3-17. Fuel Turbopump Primary Seal Drain Check Valve Reverse-Flow Test Setup

m. Disconnect pressure hose from test plate on FUEL PUMP DRAIN customer connect and disconnect test plate 9020222-11.

n. Install test plate 9020222-11 on PURGE MANIFOLD SYSTEM customer connect. Torque nuts to 61-75 in-lb.

o. Connect a pressure hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console to test plate 9020222-11.

p. Reinstall plug and seal in fitting between fuel turbopump and check valve. Torque plug to 65-70 in-lb.

q. Remove protective closure from fuel and oxidizer turbine seal drain lines.

r. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±1 psi.

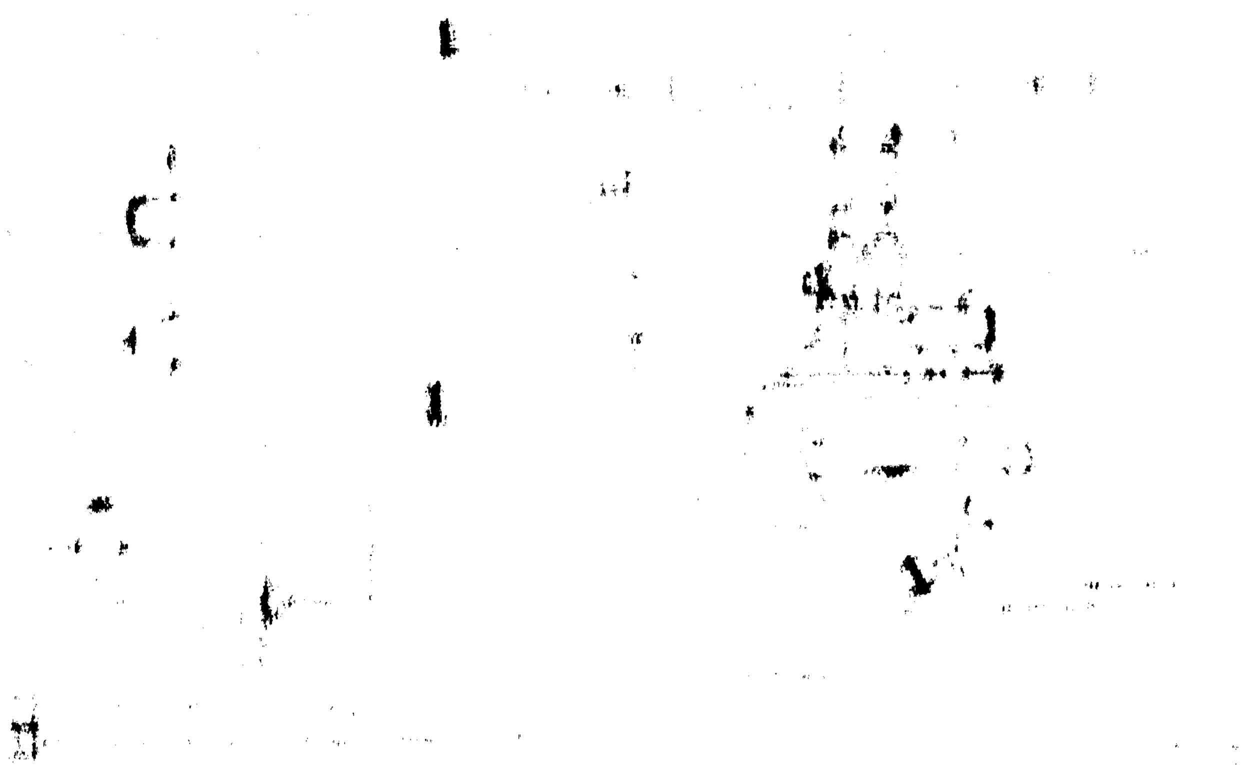
Operation	Result
s. Leak-test the fitting between fuel turbopump and turbopump primary seal drain check valve.	Leakage is not allowable.

t. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

u. Disconnect pressure hose from test plate 9020222-11 on PURGE MANIFOLD SYSTEM customer connect; then remove test plate.

v. Reinstall all protective closures removed for this test.

w. Secure pneumatic checkout console and pneumatic flowtester (paragraphs 3.3.30.4 and 3.2.30.5).



f. On engines not incorporating MD172 change, install a torque wrench to wrench adapter 9019861-11, insert through torque access, and engage splines of turbine shaft and adapter.

g. On engines incorporating MD172 change, install a torque wrench to wrench adapter 19-9025816, insert through torque access, and engage hex on turbine wheel.

h. Prepare Pneumatic Checkout Console G3106 and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.4 and 3.2.1.5).

i. Adjust facility pneumatic supply to pneumatic checkout console to 100 psig minimum.

j. Connect a pressure hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console to adapter 9025420.

k. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

l. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±1 psi.

Operation	Result
m. Using pneumatic flowtester, measure leakage from PURGE MANIFOLD SYSTEM customer connect. Record as fuel turbopump primary seal purge check valve reverse leakage.	Maximum allowable leakage is 100 scim.

CAUTION

A torque in excess of 1,000 in-lb can damage the turbopump.

Operation	Result
n. Rotate turbine wheel counterclockwise (viewed from aft end of engine) a minimum of 5 complete revolutions to determine maximum leakage point. Use pneumatic flowtester to measure leakage from fuel turbine seal drain line. Continue to rotate turbine wheel to position where maximum leakage is noted. Record as fuel turbopump secondary seal leakage.	Maximum allowable leakage is 500 scim. (See figure 3-11 for primary and secondary seal conditional leakage limits.)

o. Remove wrench and adapter, and install plug and seal on torque access opening. Torque plug to 405-445 in-lb.

p. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

q. Disconnect pressure hose from fitting between fuel turbopump and fuel turbopump primary seal drain check valve, remove adapter, and reinstall plug and seal in fitting. Torque plug to 65-70 in-lb.

r. Remove protective closure from oxidizer turbine seal drain line.

s. Connect a pressure hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console to test plate 9020222-11 on PURGE MANIFOLD SYSTEM customer connect.

t. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±1 psi.

Operation	Result
u. Leak-test the fitting between fuel turbopump and fuel turbopump primary seal drain check valve.	Leakage is not allowable.

v. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

w. Disconnect pressure hose from test plate 9020222-11 on PURGE MANIFOLD SYSTEM customer connect; then remove test plate.

x. Remove adapter from fuel turbine seal drain line.

y. Reinstall all protective closures removed for this test.

z. Disconnect pressure hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console.

aa. Secure pneumatic checkout console and pneumatic flowtester (paragraphs 3.2.30.4 and 3.2.30.5).

3.2.21 FLOW-TESTING FUEL TURBOPUMP PRIMARY SEAL DRAIN CHECK VALVE. This test consists of applying pressure to the fuel turbopump primary seal cavity to measure forward leakage and forward flow through the primary seal drain check valve. Refer to section II for checkout constraints before performing this test. See figure 3-19 for test setup.

a. The following test equipment is required:

(1) Pneumatic Flow Tester G3104.

(2) Pneumatic Checkout Console G3106.

(3) Test plate 9020222-11 (kit 9018843-11).

(4) Leak and flow adapter assembly 9025420 (adapter kit 9025419).

(5) Test plate 9019858 (kit 9016713).

b. Install test plate 9020222-11 on FUEL PUMP DRAIN customer connect. Torque nuts to 61-75 in-lb.

c. Remove plug and seal from fitting between fuel turbopump and fuel turbopump primary seal drain check valve. Install leak and flow adapter assembly 9025420. When installing adapter assembly, torque adapter 9025421 to 5 (+0, -1) in-lb and torque elbow nut on adapter to 4 (+0, -1) in-lb.

d. Prepare Pneumatic Checkout Console G3106 and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.4 and 3.2.1.5).

e. Connect a pressure hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console to adapter 9025420.

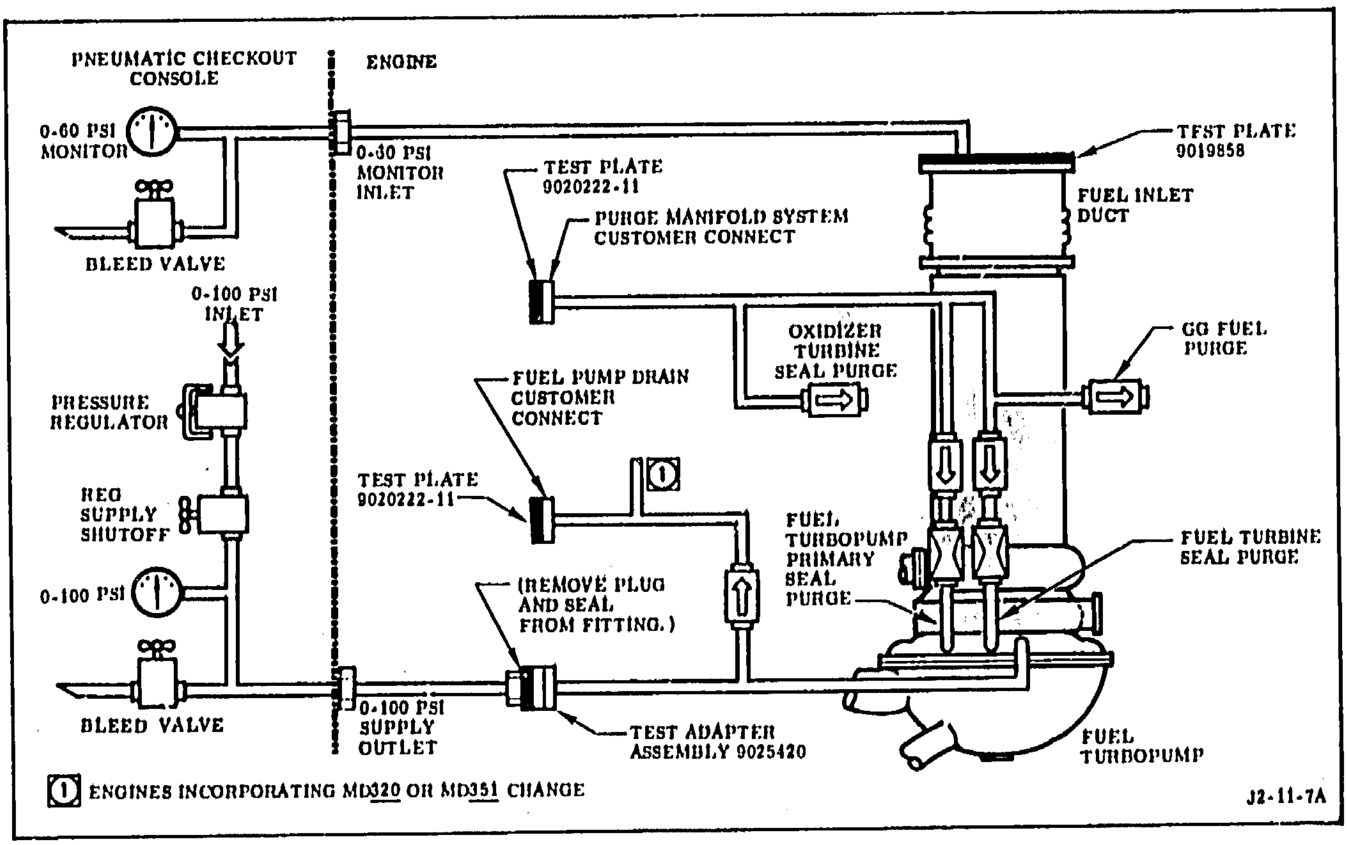


Figure 3-19. Fuel Turbopump Primary Seal Drain Check Valve Flow-Test Setup

CAUTION

Bolts specified in step f must be used to prevent galling of duct threaded inserts.

f. Using bolts RD111-1010-3616 (new bolts or bolts recoated with dry-film lubricant), install test plate 9019858 on fuel turbopump inlet duct. Torque bolts to 190-210 in-lb. Connect a pressure hose from test plate to 0-60 PSI MONITOR INLET of pneumatic checkout console.

g. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

h. Close BLEED valve on PNEUMATIC MONITOR PANEL (0-60).

i. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±1 psi.

j. Monitor the pressure indicated on PNEUMATIC MONITOR PANEL (0-60) while performing steps k and l. Pressure must not exceed 30 psig. Use BLEED valve on PNEUMATIC MONITOR PANEL (0-60), as necessary, to maintain 30 psig.

Operation	Result
k. Using pneumatic flowtester, measure flow at FUEL PUMP DRAIN customer connect. Record as fuel turbopump primary seal drain check valve forward leakage.	Maximum allowable forward leakage is 30 scim.
l. Increase pressure to 60 ±2 psig on PNEUMATIC SUPPLY PANEL (0-100). Again measure flow at FUEL PUMP DRAIN customer connect. Record as fuel turbopump primary seal drain check valve flow.	Minimum allowable flow is 2,420 scim.

m. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise.

Operation	Result
n. Open BLEED valve on PNEUMATIC MONITOR PANEL (0-60).	Pressure gage indicates zero.

o. Disconnect pressure hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console and fitting between turbopump and fuel turbopump primary seal drain check valve, remove adapter, and reinstall plug and seal in fitting. Torque plug to 65-70 in-lb.

p. Remove test plate from FUEL PUMP DRAIN customer connect, and install test plate 9020222-11 on PURGE MANIFOLD SYSTEM customer connect. Torque nuts to 61-75 in-lb.

q. Connect pressure hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console to test plate 9020222-11.

r. Remove protective closure from oxidizer and fuel turbine seal drain lines.

s. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±1 psi.

Operation	Result
t. Leak-test the fitting between fuel turbopump and fuel turbopump primary seal drain check valve.	Leakage is not allowable.

u. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

v. Disconnect pressure hose from test plate 9020222-11.

w. Disconnect pressure hose from 0-60 PSI MONITOR INLET of pneumatic checkout console and test plate on fuel turbopump inlet.

x. Remove test plates and adapters, and install protective covers removed for this test.

y. Secure pneumatic checkout console and pneumatic flowtester (paragraphs 3.2.30.4 and 3.2.30.5).

3.2.22 TESTING GAS GENERATOR OXIDIZER PURGE CHECK VALVE. This test consists of applying pressure downstream of the GG oxidizer purge check valve and measuring reverse-flow leakage. Refer to section II checkout constraints before performing this test. See figure 3-20 for GG oxidizer purge check valve test setup.

a. The following test equipment is required:

(1) Pneumatic Flow Tester G3104.

(2) Pneumatic Checkout Console G3106.

(3) Test plate 9025379 (kit 9024497).

b. Disconnect line at in-line flange and remove seal downstream of GG oxidizer purge check valve.

c. On engines incorporating MD383 or MD384 change, remove plug from oxidizer injector pressure tap CN1.

d. Install test plate 9025379 on line flange downstream of GG oxidizer purge check valve. Torque nuts to 24-30 in-lb.

e. Install a pneumatic hose from 0-100 PSI SUPPLY OUTLET on pneumatic checkout console to test plate 9025379.

f. Prepare Pneumatic Checkout Console G3106 and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.4 and 3.2.1.5).

g. Adjust pneumatic supply pressure to pneumatic checkout console to 100 psig minimum.

h. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

i. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±5 psi. Apply pressure for a minimum of 5 minutes.

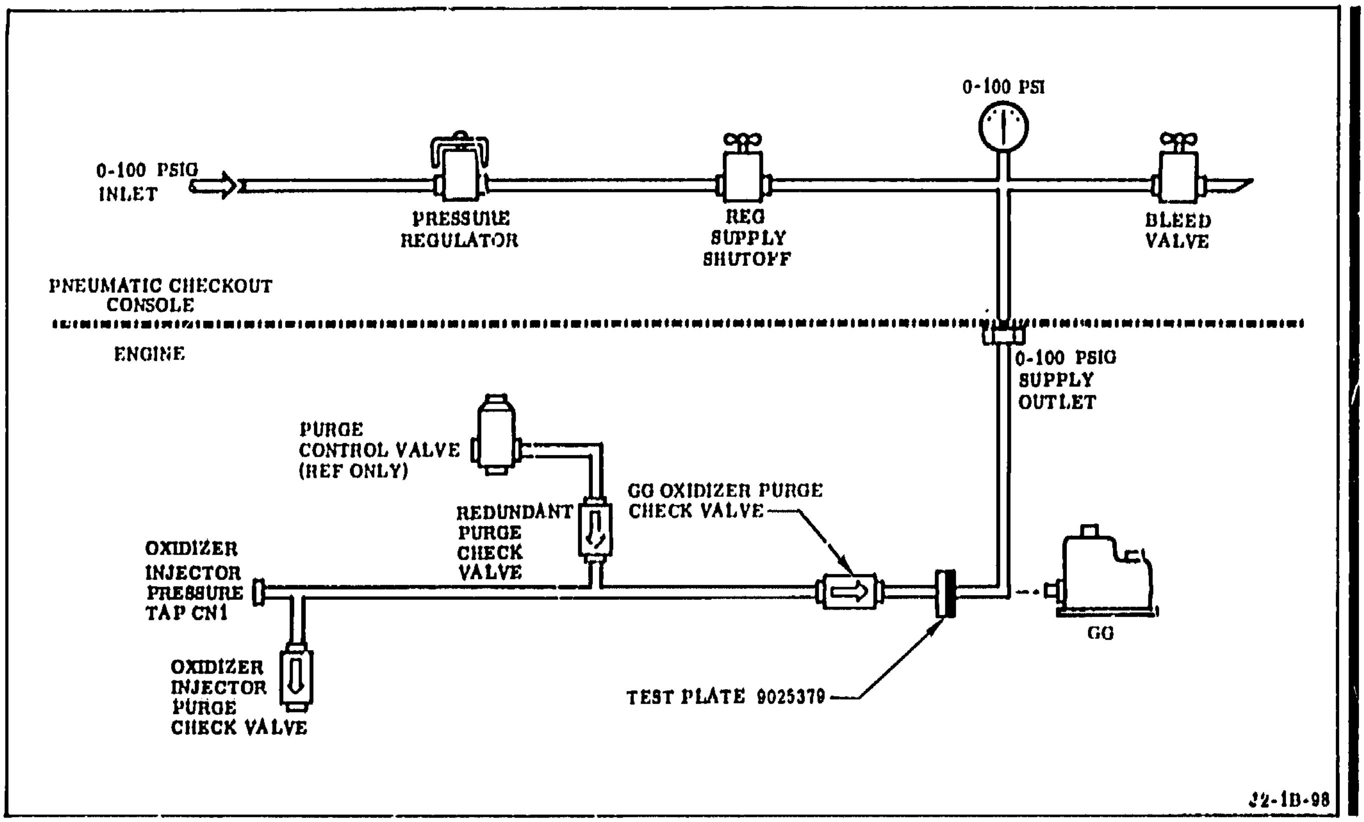


Figure 3-20. Gas Generator Oxidizer Purge Check Valve Test Setup

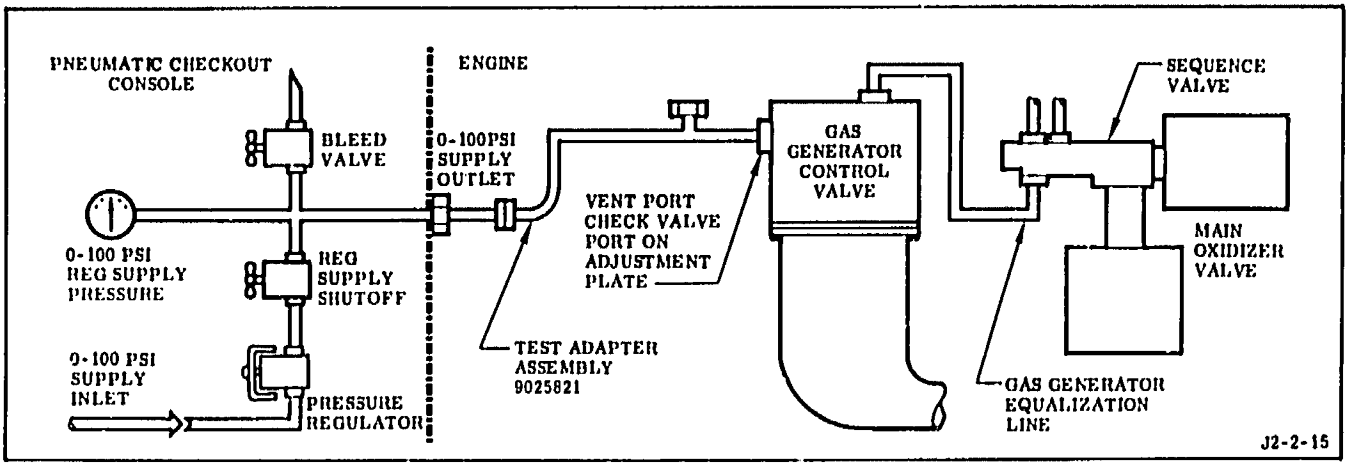


Figure 3-21. Gas Generator Equalization Line Test Setup

Operation	Result
j. Using pneumatic flowtester, measure leakage at purge control valve vent line exit or, on engines incorporating MD383 or MD384 change, at pressure tap CN1. Record actual value as GG oxidizer purge check valve reverse leakage.	Maximum allowable leakage is 15 sclm.

k. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

l. Disconnect test hose from engine and pneumatic checkout console.

m. Remove test plate from GG oxidizer purge line.

n. Install seal and connect GG oxidizer purge line. Torque bolts to 19-21 in-lb.

o. On engines incorporating MD383 or MD384 change, install new seal and reinstall plug in pressure tap CN1. Torque plug to 66-73 in-lb and safetywire.

p. Secure pneumatic checkout console and pneumatic flowtester (paragraphs 3.2.30.4 and 3.2.30.5).

3.2.22A REVERSE-LEAK-TESTING REDUNDANT PURGE CHECK VALVE (ENGINES INCORPORATING MD383 or MD384 CHANGE).

a. The following test equipment is required.

(1) Pneumatic Flow Tester G3104.

(2) Pneumatic Checkout Console G3106.

(3) Test plate 9025379 (kit 9024497).

(4) Shutoff plug 9020971 (kit 9020784-11).

b. Disconnect line at in-line flange and remove seal downstream of GG oxidizer purge check valve.

c. Install test plate 9025379 on line flange downstream of GG oxidizer purge check valve. Torque nuts to 24-30 in-lb. (Pressure cap must be installed on test plate kit.)

d. Remove valve assembly 9591-59061 from oxidizer dome purge shutoff plug 9025402 (part of shutoff plug kit 9020784-11).

e. Remove plug from oxidizer injector pressure tap CN1 and install shutoff plug 9025402 in pressure tap. Torque plug fingertight.

f. Install a pneumatic hose from 0-100 PSI SUPPLY OUTLET on pneumatic checkout console to test plug 9025402.

g. Prepare Pneumatic Checkout Console G3106 and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.4 and 3.2.1.5).

h. Remove protective closure from purge control valve vent line at thrust chamber exit.

i. Adjust pneumatic supply pressure to pneumatic checkout console to 100 psig minimum.

j. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

k. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±5 psi.

Operation	Result
1. Using pneumatic flowtester, measure leakage at purge control valve vent line exit. Record actual value as redundant purge check valve reverse leakage.	Maximum allowable leakage is 30 scim.

m. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

n. Disconnect test hose from engine and pneumatic checkout console.

o. Remove test plate from GG oxidizer purge line.

p. Install seal and connect GG oxidizer purge line. Torque bolts to 19-21 in-lb.

q. Remove shutoff plug from pressure tap CN1.

r. Install new seal and reinstall plug in pressure tap CN1. Torque plug to 66-73 in-lb and safetywire.

s. Secure pneumatic checkout console and pneumatic flowtester (paragraphs 3.2.30.4 and 3.2.30.5).

t. Install protective closure on purge control valve vent line.

u. Reinstall valve assembly 9591-59061 in shutoff plug 9025402 (removed in step d).

3.2.23 LEAK-TESTING GAS GENERATOR EQUALIZATION LINE. This test consists of pressurizing and leak-testing the GG equalization line from the GG to the sequence valve on the MOV. Refer to section II for checkout constraints before performing this test. See figure 3-21 for GG equalization line test setup.

WARNING

Ground support equipment used during this test must be operated by authorized personnel trained in the use of the equipment.

a. The following test equipment is required:

(1) Pneumatic Checkout Console G3106.

(2) Adapter kit 9024998.

b. Obtain adapter assembly 9025821, and remove elbow AN833-4J from assembly.

c. Assemble nut AN6289-4J, ring MS28777-4, and packing MS28778-4; ring and packing are in groove on elbow, and counterbore of nut faces ring.

d. Remove vent port check valve from adjustment plate of GG control valve.

e. Install elbow assembly in plate and adapter assembly on elbow.

NOTE

When interference prevents installation of elbow AN833-4J, an alternate elbow 4C50X-SS may be installed.

f. Prepare Pneumatic Checkout Console G3106 (paragraph 3.2.1.4).

g. Connect a pressure hose from adapter 9025821 to PNEUMATIC SUPPLY PANEL (0-100).

h. Adjust facility pneumatic pressure to pneumatic checkout console to 40 psig minimum.

i. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

j. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±1 psi.

Operation	Result
k. Using leak-test compound, leak-test equalization line from GG to sequence valve.	Leakage is not allowable.

l. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

m. Disconnect test hose and adapter from pneumatic checkout console and engine.

n. Secure pneumatic checkout console (paragraph 3.2.30.4).

o. Reinstall vent port check valve in boss on GG valve. (Refer to R-3825-3.)

3.2.24 TESTING PNEUMATIC CONTROL SYSTEM. This test consists of pressurizing the pneumatic control system and leak-testing the control lines associated with each control valve by energizing in sequence the helium control valve, ignition-phase control valve, and mainstage control valve. Flow tests are performed when the helium control valve or mainstage control valve is energized. The purge control valve purge lines and helium tank connections and lines are leak and flow tested. See figure 3-22 for pneumatic control system test setup. Refer to section II for checkout constraints before performing this test. The following test equipment is required:

a. Flight Instrumentation Checkout Console G1035.

b. Electrical Checkout Console G1037.

c. Pneumatic Flow Tester G3104.

d. Pneumatic Checkout Console G3106.

e. Data Recorder Console G3121.

f. Test plate 9020223 (kit 9010724).

g. Test plate 9020275 (kit 9017274).

h. Test plate 9025399 (kit 9025400-11).

i. Vent adapter 9025423 (vent adapter kit 9025424).

j. Pin puller T-5044445.

3.2.24.1 Preparing for Test.

a. Connect engine and all checkout equipment (figures 3-1 and 3-22).

b. Prepare Flight Instrumentation Checkout Console G1035, Electrical Checkout Console G1037, Data Recorder Console G3121, Pneumatic Checkout Console G3106, and Pneumatic Flow Tester G3104 for use (paragraphs 3.2.1.1 through 3.2.1.5).

c. Remove vent port check valve from fast-shutdown valve. (Check valve is located on end of valve opposite control port.)

d. Remove vent port check valve from purge control valve. (Check valve is located on end of valve opposite control port.)

e. Install test plate 9020275 on HELIUM TANK FILL customer connect. Torque nuts to 61-75 in-lb.

f. Connect a pressure hose between 0-3000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate installed on HELIUM TANK FILL customer connect.

g. Disconnect pneumatic inlet line, and remove seal from inlet port of purge control valve. Install test plate 9025399 from test plate kit 9025400-11 between pneumatic line and valve inlet port. Torque bolts to 41-45 in-lb.

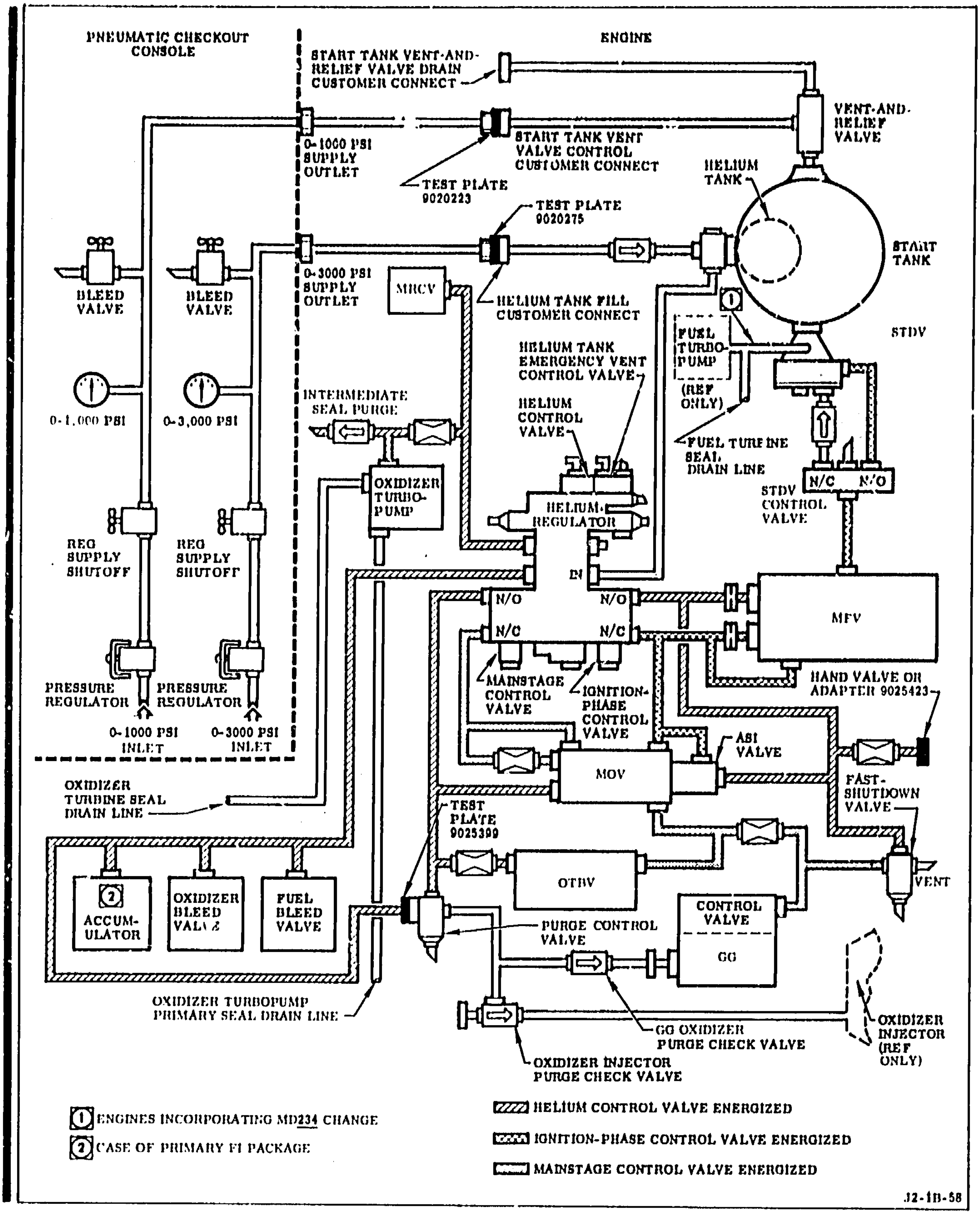


Figure 3-22. Pneumatic Control System Test Setup

h. Remove vent port check valve from boss in MFV closing control line. Connect a hand valve or vent adapter 9025423 in boss. Torque adapter to 40-50 in-lb. Close hand valve.

NOTE

The hand valve or adapter is used to eliminate flow of helium to prevent depletion of facility helium supply.

i. Remove thrust chamber exit closure or open one desiccant access opening on closure.

j. Remove protective cover from oxidizer turbine seal drain line.

k. Remove protective cover from oxidizer pump seal drain line or, on engines incorporating MD301, MD302, MD322, or MD323 change, OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.

l. Remove protective cover from oxidizer turbopump intermediate seal purge check valve.

m. Using pin puller T-5044446, remove all brass plugs from leak detection ports of system to be tested prior to start of test. Reinstall plugs after test, using tool T-5044445.

Operation	Result
n. Position PREVALVE switch to CLOSED and FACILITY READY switch to READY on engine SIMULATOR panel of electrical checkout console.	FACILITY READY light on ENGINE CONTROL panel comes on.
o. Position TEST/FIRE SELECT switch on GROUND RELAY panel of electrical checkout console to OK TO TEST.	
p. Position test selector switch on ENGINE TEST/MONITOR panel of electrical checkout console to COMPONENT TEST.	
q. Position ENGINE GROUND POWER switch on ENGINE CONTROL panel of electrical checkout console to ON.	(1) The following lights on ENGINE/TEST MONITOR panel come on: (a) COMPONENT TEST. (b) IGNITION BUS ARMED. (c) On engines incorporating ECA 502670-111 or -211, START TANK PRESSURIZED and START TANK DEPRESSURIZED. (2) The following lights on the ENGINE CONTROL panel come on: (a) ENGINE GROUND POWER. (b) MAINSTAGE OK NO. 1 DEPRESSURIZED. (c) MAINSTAGE OK NO. 2 DEPRESSURIZED. (d) TEST. (e) ENGINE READY.

r. Adjust facility pneumatic pressure to pneumatic checkout console to 1,500 psig minimum.

CAUTION

If start tank is pressurized during test, start tank pressure will spin turbopump, causing damage to equipment.

s. To make sure that start tank is not pressurized, perform steps t through ab.

t. Install test plate 9020223 on START TANK VENT VALVE CONTROL customer connect. Torque nuts to 61-75 in-lb.

u. Connect a pneumatic hose between 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate 9020223 on START TANK VENT VALVE CONTROL customer connect.

v. Remove closure from START TANK VENT & RELIEF VALVE DRAIN customer connect.

w. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-1000).

WARNING

Failure to observe the safety requirements of step x can result in injury to personnel.

Operation	Result
x. Clear personnel from area of START TANK VENT & RELIEF VALVE DRAIN customer connect; then turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until REG SUPPLY PRESSURE gage indicates 250 psi maximum.	Any pressure in the start tank must vent through the START TANK VENT & RELIEF VALVE DRAIN customer connect.

y. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

z. Disconnect pneumatic hose from 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate 9020223 on START TANK VENT VALVE CONTROL customer connect, and install pressure cap on 0-1000 PSI SUPPLY OUTLET.

aa. Remove test plate from START TANK VENT VALVE CONTROL customer connect and install protective closure.

ab. Install closure on START TANK VENT & RELIEF VALVE DRAIN customer connect.

3.2.24.2 Leak and Flow Testing With Helium Control Valve Energized. (See figure 3-23 for leak-test point locations.)

a. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-3000).

Operation	Result
b. Position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to ON.	(1) Event recorder pen 4 picks up. (2) HELIUM CONTROL light comes on.
c. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) to INCREASE until REG SUPPLY PRESSURE gage indicates 225-250 psi.	Event recorder pens 34 and 35 pick up.

NOTE

Audible helium flow from the engine regulator bleed port is allowable.

d. If system must be depressurized before completion of this procedure, turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) fully counterclockwise, and using hand valve on vent adapter 9025423 in boss in MFV closing control line, vent pressure from control system.

Operation	Result
e. Using pneumatic flowtester or leak-test compound, as applicable, leak-test those connections and lines in pneumatic control system that are pressurized when helium control valve is energized.	Leakage is not allowable.
f. Leak-test oxidizer turbopump intermediate seal purge line.	Leakage is not allowable.
g. Using pneumatic flowtester, measure leakage from vent port of fast-shutdown valve. Record value as fast-shutdown valve diaphragm leakage. If leakage exceeds 3 scim, perform steps h through l. If leakage rate is 3 scim or less, proceed to step m.	Maximum allowable leakage is 3 scim.

Leak-Test Point Description	Location Code in Figure 3-32	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
HELIUM CONTROL VALVE ENERGIZED			
Oxidizer bleed valve closing control port	P1	X	
MOV closing control port	P3	X	
MOV thermal compensating orifice flange	P37	X	
ASI valve closing control port	P12	X	
Mainstage control valve connection to mainstage control valve manifold	P13	X	
Helium regulator assembly regulated pressure outlet port NN2	P14	X	
NN2 line to auxiliary FI package			X
NN2 line from tee to static-test transducer			X
Helium regulator assembly high-pressure inlet line NN1	P15	X	
NN1 line to primary FI package			X
NN1 line to auxiliary FI package[a]			X
NN1 line from tee to static-test transducer			X
Ignition-phase control valve connection to ignition-phase control valve manifold	P16	X	
Helium regulator assembly bleed valve control and accumulator line outlet flange	P17	X	
Pneumatic accumulator inlet line flange (primary FI package) (2 places)	P20	X	
OTBV opening control port	P22	X	
MFV closing control port	P26	X	
Helium tank temperature transducer NNT1	P28	X	

(a) Engines incorporating MD269, MD282, MD296, MD313, or MD315 change.

Figure 3-23. Pneumatic Control System Leak-Test Points (Sheet 1 of 2)

Leak-Test Point Description	Location Code in Figure 3-32	[illegible]	[illegible]
HELIUM CONTROL VALVE ENERGIZED (cont)			
Helium tank connection to helium cover and fill-check valve	P29	X	
Fuel bleed valve closing control port	P35	X	
MRCV pneumatic inlet port(b)	P38	X	
IGNITION-PHASE CONTROL VALVE ENERGIZED			
MOV sequence valve inlet port	P6	X	
ASI valve opening control port	P11	X	
MFV opening control port	P23	X	
MFV sequence valve inlet port	P24	X	
MFV sequence valve outlet port	P25	X	
STDV closing control port	P31	X	
STDV CONTROL VALVE ENERGIZED			
STDV opening control port	P30	X	
STDV control valve connection to adapter	P32	X	
MAINSTAGE CONTROL VALVE ENERGIZED			
MOV second-stage actuator (opening control) port	P2	X	
MOV sequence valve connection to MOV sequence valve end plate (sequence valve inlet)	P4	X	
MOV first-stage actuator (opening control) port	P5	X	
MOV sequence valve connection to adapter	P7	X	
MOV sequence valve adapter (connection to GG and fast-shutdown valve inlet line)	P8	X	
MOV sequence valve adapter (connection to OTBV closing control line)	P9	X	
OTBV closing control port	P21	X	
Fast-shutdown valve inlet port	P33	X	
GG opening control port	P34	X	

(b) Engines incorporating MD366 or MD371 change.

Figure 3-23. Pneumatic Control System Leak-Test Points (Sheet [illegible])

Operation	Result
h. Position START TANK DISCHARGE CONTROL switch on ENGINE TEST/ MONITOR panel to ON.	(1) START TANK DISCH CONTROL light comes on. (2) DIGITAL VOLT-OHMMETER indicates 4.500 ±0.400 volts. (3) Event recorder pens 9 and 11 pick up and pen 10 drops out.
i. Using pneumatic flowtester, leak-test applicable connections in pneumatic control system with STDV control valve energized.	Leakage is not allowable.
j. Press RELEASE button on VALVE POSITION TEST section of CALIBRATION CONTROL panel.	CHANNEL NO. 4 button releases, and light goes off.
k. Position START TANK DISCHARGE CONTROL switch on ENGINE TEST/ MONITOR to OFF.	(1) START TANK DISCH CONTROL light goes off. (2) Event recorder pen 10 picks up and pens 9 and 11 drop out.

3.2.24.4 Leak and Flow Testing With Main-Stage Control Valve Energized. (See figure 3-23 for leak-test point locations.)

Operation	Result
a. Position MAIN-STAGE CONTROL switch on ENGINE TEST/MONITOR panel to ON.	(1) MAINSTAGE CONTROL light comes on. (2) Event recorder pens 12, 18, 17, and 15 pick up and pens 13, 19, and 16 drop out.
b. Using pneumatic flowtester, leak-test applicable connections and lines in pneumatic control system with mainstage control valve energized.	Leakage is not allowable.
c. Using pneumatic flowtester, measure leakage from vent port of fast-shutdown valve. Record as fast-shutdown valve seat leakage.	Maximum allowable leakage is 10 scim.
d. Press CHANNEL No. 2 button on VALVE POSITION TEST section of CALIBRATION CONTROL panel.	(1) CHANNEL NO. 2 button lights. (2) DIGITAL VOLT-OHMMETER indicates 4.500 ±0.400 volts.
e. Press the following switches on VALVE POSITION TEST SECTION of CALIBRATION CONTROL panel:	
(1) RELEASE button.	(1) CHANNEL NO. 2 button releases, and light goes off.
(2) CHANNEL NO. 5 button.	(2) CHANNEL NO. 5 button lights, and DIGITAL VOLT-OHMMETER indicates 0.500 ±0.400 volts.
(3) RELEASE button	(3) CHANNEL NO. 5 button releases, and light goes off.
f. Position the following switches on ENGINE TEST/ MONITOR panel to OFF:	
(1) MAIN-STAGE CONTROL.	(1) MAINSTAGE CONTROL light goes off. Event recorder pens 12, 15, 17, and 18 drop out and pens 13, 16, and 19 pick up.
(2) IGNITION PHASE CONTROL.	(2) IGNITION PHASE CONTROL light goes off. Event recorder pens 5, 7, and 8 drop out and pen 6 picks up.

g. Turn PRESSURE REGULATOR on PNEUMATIC PANEL (0-3000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

Operation	Result
h. Using hand valve or vent adapter 9025423 in boss in MFV closing control line, vent pressure from control system. After all pressure has vented, close hand valve.	Pens 34 and 35 drop out.
i. Position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	HELIUM CONTROL light goes off, and event recorder pen 4 drops out.
j. Press CHANNEL NO. 1 button on VALVE POSITION TEST section of CALIBRATION CONTROL panel.	(1) CHANNEL NO. 1 button lights. (2) DIGITAL VOLTOHMMETER indicates 0.500 ±0.400 volt.
k. Press RELEASE button on VALVE POSITION TEST section of CALIBRATION CONTROL panel.	CHANNEL NO. 1 button releases, and light goes off.
l. Repeat steps j and k for CHANNEL NO. 2 through CHANNEL NO. 5.	DIGITAL VOLTOHMMETER indication for CHANNEL NO. 5 is 4.500 ±0.400 volts.
m. Press VALVE POSITION SELECT switch-light.	VALVE POSITION SELECT switch-light goes off.

3.2.24.5 Leak- and Flow-Testing Purge Control Valve Seat Leakage and Purge Lines. (See figure 3-32 for locations of leak-test points.)

a. Remove test plate kit 9025400-11 from between inlet port of purge control valve and inlet line. Install seal and connect inlet line to purge control valve. Torque bolts to 41-45 in-lb.

b. Close hand valve or adapter 9025423 in boss of MFV closing control line.

Operation	Result
c. Position HELIUM CONTROL and MAINSTAGE CONTROL switches on ENGINE TEST/MONITOR panel to ON.	HELIUM CONTROL and MAINSTAGE CONTROL lights come on.

d. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) to INCREASE until REG SUPPLY PRESSURE gage indicates 225-250 psi.

Operation	Result
e. Using pneumatic flowtester, measure leakage from purge control valve vent port. Record leakage as purge control valve seat leakage.	Maximum allowable leakage is 10 scim.
f. Leak-test purge control valve inlet line flange (P19).	Leakage is not allowable.
g. Position MAINSTAGE CONTROL switch on ENGINE TEST/MONITOR to OFF.	MAINSTAGE CONTROL light goes off.

h. Make sure that purge control valve shuttles by checking for audible flow of gas at valve vent line exit. If gas flow is detected, position MAINSTAGE CONTROL switch on ENGINE TEST/MONITOR panel to ON (MAINSTAGE CONTROL light comes on). If gas flow is not detected, disregard steps i through l and perform step m.

WARNING

Failure to observe the safety requirements of step i can result in injury to personnel.

i. Clear area of all personnel. Personnel must stand behind safety barriers or at a safe distance from the engine when steps j through l are being performed.

j. Using PNEUMATIC SUPPLY panel (0-3000), increase pneumatic control system pressure to 400 ±25 psig.

Operation	Result
k. Position MAINSTAGE CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	MAINSTAGE CONTROL light goes off.

l. Using PNEUMATIC SUPPLY panel (0-3000), decrease pneumatic control system pressure to 225-250 psig.

Operation	Result
m. Leak-test purge control valve outlet line flange (P18) and purge lines from purge control valve to:	Leakage is not allowable.

(1) Oxidizer injector purge pressure tap CN1 (dome) (P10).

(2) GG oxidizer purge line flange (P27).

(3) GG oxidizer injector pressure and purge line pressure instrumentation port GO5 (L40) on GG.

Operation	Result
n. Close REG SUPPLY SHUTOFF valve and open BLEED valve on PNEUMATIC SUPPLY PANEL (0-3000).	REG SUPPLY PRESSURE gage indicates zero.

o. Using hand valve or vent adapter 9025423 in boss in MFV closing control line, vent pressure from control system. After all pressure has vented, close hand valve.

Operation	Result
p. Position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	HELIUM CONTROL light goes off.
q. Press INSTRUMENT BUS POWER ON switch-light on CALIBRATION CONTROL panel.	(1) INSTRUMENT BUS POWER ON light goes off. (2) STANDBY portion of INSTRUMENT BUS POWER ON switch-light comes on. (3) 28 VDC POWER ON light on SIGNAL CONDITIONER panel goes off.
r. Press CONSOLE POWER ON switch-light on CALIBRATION CONTROL panel.	(1) CONSOLE POWER ON light goes off. (2) STANDBY portion of CONSOLE POWER ON switch-light comes on. (3) STANDBY portion of INSTRUMENT BUS POWER ON switch-light goes off. (4) 115VAC POWER ON light on SIGNAL CONDITIONER panel goes off.
s. Turn POWER switch on power supply panel to OFF.	All remaining lights on flight instrumentation checkout console go off.

3.2.24.6 <u>Leak- and Flow-Testing Helium Tank Connections and Lines.</u> (See figure 3-32 for location of leak-test points.)

a. Slowly turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) to INCREASE until REG SUPPLY PRESSURE gage indicates 1,400-1,600 psi.

Operation	Result
b. Leak-test connections and welds from helium tank to the following:	Leakage is not allowable.

(1) Pneumatic control package (P29 and P15).

(2) HELIUM TANK FILL customer connect.

Operation	Result
(3) Helium tank pressure line NN1 (P15) to primary and auxiliary FI packages and from tee in line to static-test transducer.	

c. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

d. Disconnect pressure hose from 0-3000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate installed on HELIUM TANK FILL customer connect.

e. Remove test plate from HELIUM TANK FILL customer connect.

Operation	Result
f. Using pneumatic flowtester, measure leakage at HELIUM TANK FILL customer connect. Record as helium tank fill-check valve reverse leakage.	Maximum allowable leakage is 3 scim.
g. Position EMERG HELIUM TANK VENT switch on ENGINE CONTROL panel to ON.	EMERG HELIUM TANK VENT light comes on. All pressure in helium tank vents.

h. Using hand valve or vent adapter 9025423 in boss in MFV closing control line, vent pressure from control system. After all pressure has vented, close hand valve.

Operation	Result
i. Position EMERG HELIUM TANK VENT switch on ENGINE CONTROL panel to OFF.	EMERG HELIUM TANK VENT light goes off.
j. Position the following switches on electrical checkout console to OFF.	All lights on electrical checkout console go off.

(1) Test selector on ENGINE TEST/MONITOR panel.

(2) TEST/FIRE SELECT on GROUND RELAY panel.

(3) ENGINE GROUND POWER on ENGINE CONTROL panel.

k. Position FACILITY READY switch on SIMULATOR panel to NOT READY.

3.2.24.7 Securing After Test. If another test is to be performed, the removal of test equipment required for that test may be disregarded.

a. Remove hand valve or vent adapter from boss in MFV closing control line.

b. Reinstall vent port check valve in boss in MFV closing control line. (Refer to R-3825-3.)

c. Reinstall vent port check valve in fast-shutdown valve. (Refer to R-3825-3.)

d. Reinstall vent port check valve in purge control valve. (Refer to R-3825-3.)

e. Reinstall protective closures removed for this test.

f. Reinstall brass plugs in leak detection ports removed for this test, using tool T-5044445.

g. Secure flight instrumentation checkout console, electrical checkout console, data recorder console, pneumatic checkout console, and pneumatic flowtester (paragraphs 3.2.30.1 through 3.2.30.5).

3.2.25 TESTING HELIUM SUPPLY SYSTEM FOR MASS LOSS. This test consists of pressurizing the helium tank and checking helium loss over a given span of time. Refer to section II for checkout constraints before performing this test. The following test equipment is required:

a. Flight Instrumentation Checkout Console G1035.

b. Electrical Checkout Console G1037.

c. Pneumatic Checkout Console G3106.

d. Data Recorder Console G3121.

e. Test plate 9020275 (kit 0017274).

3.2.25.1 Preparing For Test.

a. Connect engine and all checkout equipment (figure 3-1).

b. Prepare Flight Instrumentation Checkout Console G1035, Electrical Checkout Console G1037, Data Recorder Console G3121, and Pneumatic Checkout Console G3106 (paragraphs 3.2.1.1 through 3.2.1.4).

c. Install test plate 9020275 on HELIUM TANK FILL customer connect. Torque nuts to 61-75 in-lb.

d. Connect a pressure hose between 0-3000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate installed on HELIUM TANK FILL customer connect.

e. Position POWER switch to ON and MODE switch to CONT. SCAN. on DIGITAL VOLT-OHMMETER panel of flight instrumentation checkout console.

f. Remove thrust chamber exit closure, or open one desiccant access cover on closure.

g. Remove the following protective covers from the oxidizer turbopump:

(1) Turbine seal drain line.

(2) Intermediate seal purge check valve vent.

(3) Primary seal drain (at thrust chamber exit) or, on engines incorporating MD301, MD302, MD322, or MD323 change, OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.

h. Adjust facility helium supply to 1,600 psig.

3.2.25.2 Mass-Loss Testing.

a. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-3000).

b. Slowly turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) to INCREASE until REG SUPPLY PRESSURE gage indicates 1,500 (+100, -0) psi.

c. Record time step b was performed.

d. Wait one hour after initial helium tank pressurization time recorded in step c.

e. Observe REG SUPPLY PRESSURE gage on PNEUMATIC SUPPLY PANEL (0-3000). Pressure must be 1,500 (+100, -0) psi. If pressure is not within limits, adjust PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) until pressure gage indicates 1,500 (+100, -0) psi.

NOTE

A printout may be obtained by momentarily turning the POWER switch on the DIGITAL VOLT-OHMMETER to PRINT.

Operation	Result
f. Press TEMPERATURE SELECT switch and CHANNEL NO. 10 button on flight instrumentation checkout console. Record DIGITAL VOLT-OHMMETER indication.	Temperature must be 120° F (5.107 volts) or less.

NOTE

To select PRESSURE SELECT when TEMPERATURE SELECT is actuated, the SPEED AND FLOW SELECT button must be pressed twice to deactuate TEMPERATURE SELECT.

g. If temperature is not within allowable limits, allow a cooling or stabilizing period; then repeat steps e and f until all conditions have been met.

NOTE

Steps h and i remove supply pressure to helium tank system.

Operation	Result
h. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) fully counterclockwise.	REG SUPPLY PRESSURE gage indicates zero.

i. Close REG SUPPLY SHUTOFF valve and open BLEED valve. Maintain BLEED valve open during mass-loss test.

j. Press PRESSURE SELECT switch and CHANNEL NO. 5 button on flight instrumentation checkout console. Record DIGITAL VOLT-OHMMETER indication.

k. Press TEMPERATURE SELECT switch and CHANNEL NO. 10 button on flight instrumentation checkout console. Record DIGITAL VOLT-OHMMETER indication.

l. Record time readings in steps j and k were obtained. Determine and record helium mass (M) using the following formula:

$$M = \frac{1.68PV}{TV + 1.222}$$

where

M = mass (pounds)
PV = pressure indication (volts)
TV = temperature indication (volts)

m. Wait exactly one hour; then obtain and record DIGITAL VOLT-OHMMETER values for pressure and temperature. Determine mass using formula in step l.

NOTE

If a net mass gain of zero to 0.005 pound is obtained, helium tank mass leakage must be recorded as zero.

- If a net mass gain of greater than 0.005 pound is obtained, the one-hour-interval mass-loss test must be repeated.

Operation	Result
n. Subtract value obtained in step m from value obtained in step l. Record as helium tank mass-loss leakage.	Maximum allowable loss in mass is 0.036 pound (in one hour).
o. Position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to ON.	HELIUM CONTROL light comes on.
p. When all pressure has vented from tank, position HELIUM CONTROL switch to OFF.	HELIUM CONTROL light goes off.

3.2.25.3 Securing After Test.

a. Disconnect test hose from pneumatic checkout console 0-3000 PSI SUPPLY OUTLET and engine test plate 9020275.

b. Remove test plate 9020275 from HELIUM TANK FILL customer connect, and install protective covers.

c. Install thrust chamber exit closure, or close desiccant access cover on closure.

d. Install all protective covers removed for this test.

e. Secure flight instrumentation checkout console, electrical checkout console, data recorder console, and pneumatic checkout console (paragraphs 3.2.30.1 through 3.2.30.4).

3.2.26 TESTING GAS GENERATOR AND EXHAUST SYSTEM. This test consists of pressurizing and leak-testing the system, then measuring the leakage past the fuel and oxidizer turbine seals. Test plates that seal the exhaust system are installed in the exhaust duct to maintain test pressure. See figure 3-24 for GG and exhaust system test setup. Refer to section II for checkout constraints before performing this test. The following test equipment is required:

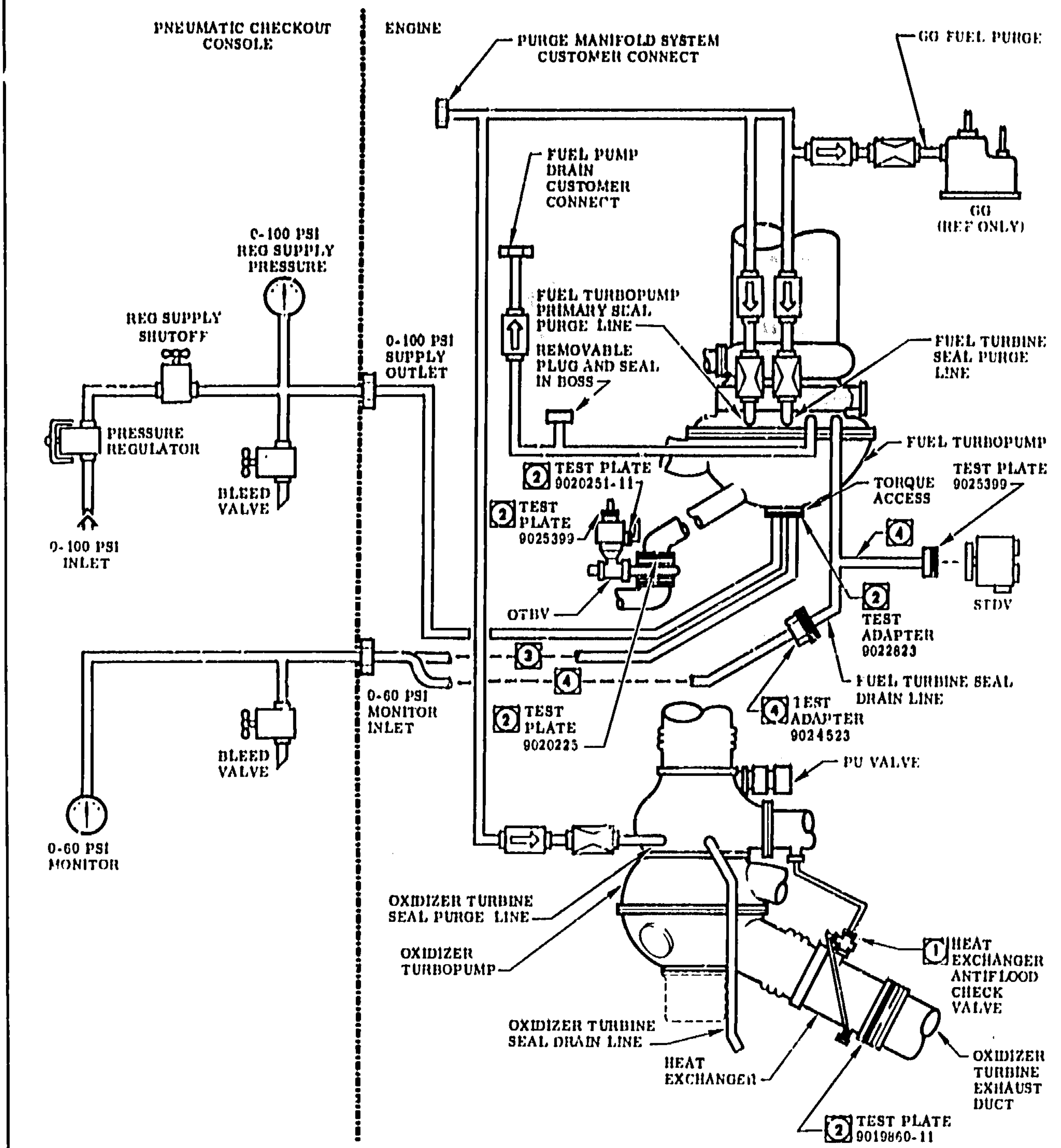
a. Pneumatic Flow Tester G3104.

b. Pneumatic Checkout Console G3106.

c. On engines incorporating MD234 change, test plate 9025399 (kit 9025400-11).

d. On engines incorporating MD234 change, test adapter 9024523 (adapter kit 9024496).

e. On engines incorporating MD172 change, wrench adapter 19-9025816 (wrench adapter kit 9016711-21).



1 ENGINES NOT INCORPORATING MD105 OR MD194 CHANGE

2 EXHAUST SYSTEM TEST PLATES INSTALLATION

3 ENGINES NOT INCORPORATING MD234 CHANGE

4 ENGINES INCORPORATING MD234 CHANGE (LEAK-TEST DRAIN LINE FLANGE OF STDV)

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Figure 3-24. Gas Generator and Exhaust System Test Setup

f. On engines not incorporating MD172 change, wrench adapter 9019861-11 (wrench adapter kit 9016711-11)

g. Exhaust system test plates and equipment:

(1) Test plate 9019860-11 (kit 9016710-11).

(2) Test plate 9020251-11 (kit 9016723-11).

(3) Adapter 9022823 (adapter kit 9018846).

(4) Test plate 9025399 (kit 9025400-11).

(5) Heat exchanger handler 9016790-11.

(6) Bypass valve removal tool 9020260.

(7) Duct flange brackets 9021015 and 9021016.

(8) Test plate 9020225 (kit 9016701-11).

3.2.26.1 Preparing for Test.

a. Prepare Pneumatic Checkout Console G3106 and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.4 and 3.2.1.5).

b. Remove plug and seal from torque access of fuel turbine exhaust duct.

c. On engines not incorporating MD172 change, install torque wrench to adapter 9019861-11, insert through torque access, and engage splines of turbine shaft and adapter.

d. On engines incorporating MD172 change, install torque wrench to adapter 10-9025816, insert through torque access, and engage hex on turbine wheel.

e. Rotate turbine wheel counterclockwise (viewed from turbine) a minimum of 5 complete revolutions.

f. Remove torque wrench and adapter.

g. Install exhaust system test plates as outlined in paragraph 3.2.2.

h. Install pressure hoses between 0-100 PSI SUPPLY OUTLET and 0-60 MONITOR INLET of pneumatic checkout console and test adapter 9022823 installed at the torque access of fuel turbine exhaust duct.

i. Remove protective covers from oxidizer and fuel turbine seal drain lines.

j. On engines incorporating MD234 change, remove bolts and washers that secure drain line to STDV, and remove seal.

k. Install test plate 9025399 from test plate kit 9025400-11 between drain line flange and STDV drain line boss. Torque bolts to 41-45 in-lb.

l. Remove threaded plugs from leak detection ports as required during system test.

3.2.26.2 Leak Testing. (See figure 3-25 for leak-test point locations.)

a. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

b. Close BLEED valve on PNEUMATIC MONITOR PANEL (0-60).

CAUTION

System pressure must not exceed 35 psig.

c. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until pressure gage on PNEUMATIC MONITOR PANEL (0-60) indicates 30 ±1 psi.

Operation	Result
d. Using pneumatic flowtester, measure leakage at oxidizer turbine seal drain line. Record as oxidizer turbine seal leakage.	Maximum allowable leakage is 350 scim.
e. Connect hose from flowtester to fuel turbine seal drain line. Record as fuel turbine seal leakage. If range of flowtester is exceeded, use 2 flowtesters in parallel. (Refer to R-3825-5.)	Allowable leakage is 6,000 scim in excess of leakage recorded in Engine Log Book during engine final acceptance checkout (form DD250 signoff), but not to exceed a

Leak-Test Point Description	Location Code in Figure 3-32	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
Fuel turbine exhaust duct connection to oxidizer turbine inlet	G1[a]	X	
Oxidizer turbine inlet temperature transducer TGT3[b]	G2[c]	X	
Oxidizer turbine inlet pressure instrumentation port TG3	G3[c]	X[d]	X[e]
TG3 line to auxiliary FI package			X
Oxidizer turbopump torque-access cover plate	G4[f]	X	
Oxidizer turbopump accessory drive pad connection to turbine exhaust duct	G5[f]	X	
Oxidizer turbopump accessory drive pad access plug	G6[f]	X	
Oxidizer turbopump connection to heat exchanger	G7[a]	X	
Oxidizer turbine exhaust pressure instrumentation port TG4	G8[c]	X[d]	X[e]
TG4 line to auxiliary FI package			X
TG4 line from tee to static-test transducer			X
Oxidizer turbine exhaust temperature transducer TGT4[b]	G9[c]	X	
Heat exchanger pressure instrumentation port HG2[d]	G10[c]	X	
Heat exchanger temperature transducer port HGT2[d]	G11[c]	X	
OTBV inlet pressure instrumentation port TGT8[d]	G15[c]	X	
TG8 line to static-test transducer[g]			X

(a) Maximum allowable leakage is 3 scim.
(b) On engines incorporating MD263 change but not incorporating MD274 change, transducer port is plugged.
(c) Maximum allowable leakage is 0.3 scim.
(d) Engines not incorporating MD237 change.
(e) Engines incorporating MD237 change.
(f) Maximum allowable leakage is one scim.
(g) Engines not incorporating MD226 change.

Figure 3-25. Gas Generator and Exhaust System Leak-Test Points (Sheet 1 of 3)

Leak-Test Point Description	Location Code in Figure 3-32	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
OTVB inlet temperature transducer port TGT6(d)	G16(c)	X	
GG chamber pressure instrumentation port GG1a(d)	G17(c)		X
GG1a line to static-test instrumentation transducer(d)			X
GG chamber pressure instrumentation port GG1(d)	G18(c)	X	
GG1 line to primary FI package(d)			X
Fuel turbine inlet pressure instrumentation port (acceptance) TG1a(h)	G19(c)	X	
Fuel turbine inlet temperature transducer port TGT1a(d)	G20(c)	X	
Fuel turbine inlet pressure instrumentation port (acceptance) TG1(d) (h)	G21(c)	X	
Fuel turbine inlet manifold connection to STDV hose	G22(f)	X	
GG spark igniter "A" port	G23(c)	X	
Fuel turbine inlet temperature transducer TGT1(b)	G24(c)	X	
GG overtemperature transducer GGT1	G25(c)	X	
Fuel turbine exhaust temperature transducer port TGT2	G26(c)	X	
Fuel turbine exhaust pressure instrumentation port TG2	G27(c)	X	
Fuel turbine exhaust duct drain port	G28	X	
Fuel turbopump connection to turbine exhaust duct	G29(a)	X	

(a) Maximum allowable leakage is 3 scim.
(b) On engines incorporating MD203 change but not incorporating MD274 change, transducer port is plugged.
(c) Maximum allowable leakage is 0.3 scim.
(d) Engines not incorporating MD237 change.
(f) Maximum allowable leakage is one scim.
(h) Engines not incorporating MD136 change.

Figure 3-25. Gas Generator and Exhaust System Leak-Test Points (Sheet 2 of 3)

Leak-Test Point Description	Location Code in Figure 3-32	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
STDV drain line connection to STDV	G32	X[i]	
STDV connection to STDV hose	F42	X	
Instrumentation port on STDV discharge hose	F53	X	
GG fuel valve connection to injector	F43	X	
GG fuel injector pressure and purge line pressure instrumentation port GF4	F44[c]	X	
GF4 line to auxiliary FI package			X
GF4 line from tee to static-test transducer			X
GG oxidizer valve connection to injector	L39	X	
GG oxidizer injector pressure and purge line pressure instrumentation port GO5	L40	X	
GO5 line to auxiliary FI package			X
GO5 line from tee to static-test transducer			X
GG oxidizer purge line flange	P27	X	
GG spark igniter "B" port	G30[c]	X	
Fuel turbine inlet temperature transducer port TGT1b[d]	G31[c]	X	
Fuel turbine inlet pressure instrumentation port TG1[j]	G31[c]	X	
TG1 line to primary FI package[k]			X

(c) Maximum allowable leakage is 0.3 scim.
(d) Engines not incorporating MD237 change.
(i) On engines incorporating MD234 change, leak test must be performed after drain line is reconnected.
(j) On engines incorporating MD237 change, TGT1b is changed to TG1.
(k) On engines incorporating MD237 change, GG1 on primary FI package is changed to TG1.

Figure 3-25. Gas Generator and Exhaust System Leak-Test Points (Sheet 3 of 3)

Operation	Result
	maximum of 10,000 scim. If fuel turbine seal has been replaced, maximum allowable leakage is 6,000 scim in excess of leakage recorded in Engine Log Book for first leak check performed after seal replacement, but not to exceed a maximum value of 10,000 scim. (Refer to R-3825-3 for seal replacement.)
f. Using pneumatic flowtester or leak-test compound, as applicable, leak-test applicable connections and lines of GG body and oxidizer turbine exhaust system (figure 3-25).	Leakage is not allowable, unless otherwise noted in figure 3-25.
g. Using pneumatic flowtester, measure reverse-flow leakage of GG fuel purge check valve at PURGE MANIFOLD SYSTEM customer connect. Record as GG fuel purge check valve reverse leakage. If fuel turbine seal purge check valve reverse leakage recorded in paragraph 3.2.10 exceeded 100 scim and exhaust system test plates were installed, subtract leakage recorded in this step from leakage recorded in paragraph 3.2.10. Record difference as fuel turbine seal purge check valve reverse leakage.	Maximum allowable leakage is 100 scim.

h. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

i. On engines incorporating MD234 change, perform steps j through p. On engines not incorporating MD234 change, proceed to paragraph 3.2.26.3.

j. Remove bolts and washers that secure drain line and test plate to valve. Remove test plate. Install seal, and connect drain line to STDV with bolts and washers. Torque bolts to 42-45 in-lb, and safetywire.

k. Install test adapter 9024523 on exit end of fuel turbine seal drain line (at thrust chamber exit). Torque hose clamp to 12-15 in-lb.

l. Disconnect pneumatic monitor hose from test adapter 0022823, and connect pneumatic monitor hose to adapter 9024523 on fuel turbine seal drain line.

m. Install cap on fitting of test adapter 0022823 installed on torque access of fuel turbine exhaust duct.

n. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until pressure gage on PNEUMATIC MONITOR PANEL (0-60) indicates 30 ±1 psi.

Operation	Result
o. Leak-test drain flange at STDV (G32).	Leakage is not allowable.

p. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

3.2.26.3 Securing After Test. If another test is to be performed, removal of test equipment required for that test may be disregarded.

a. Disconnect test hoses from pneumatic checkout console and engine.

b. On engines incorporating MD234 change, remove test adapter 9024523 from exit end of fuel turbine seal drain line, and install protective closure on line.

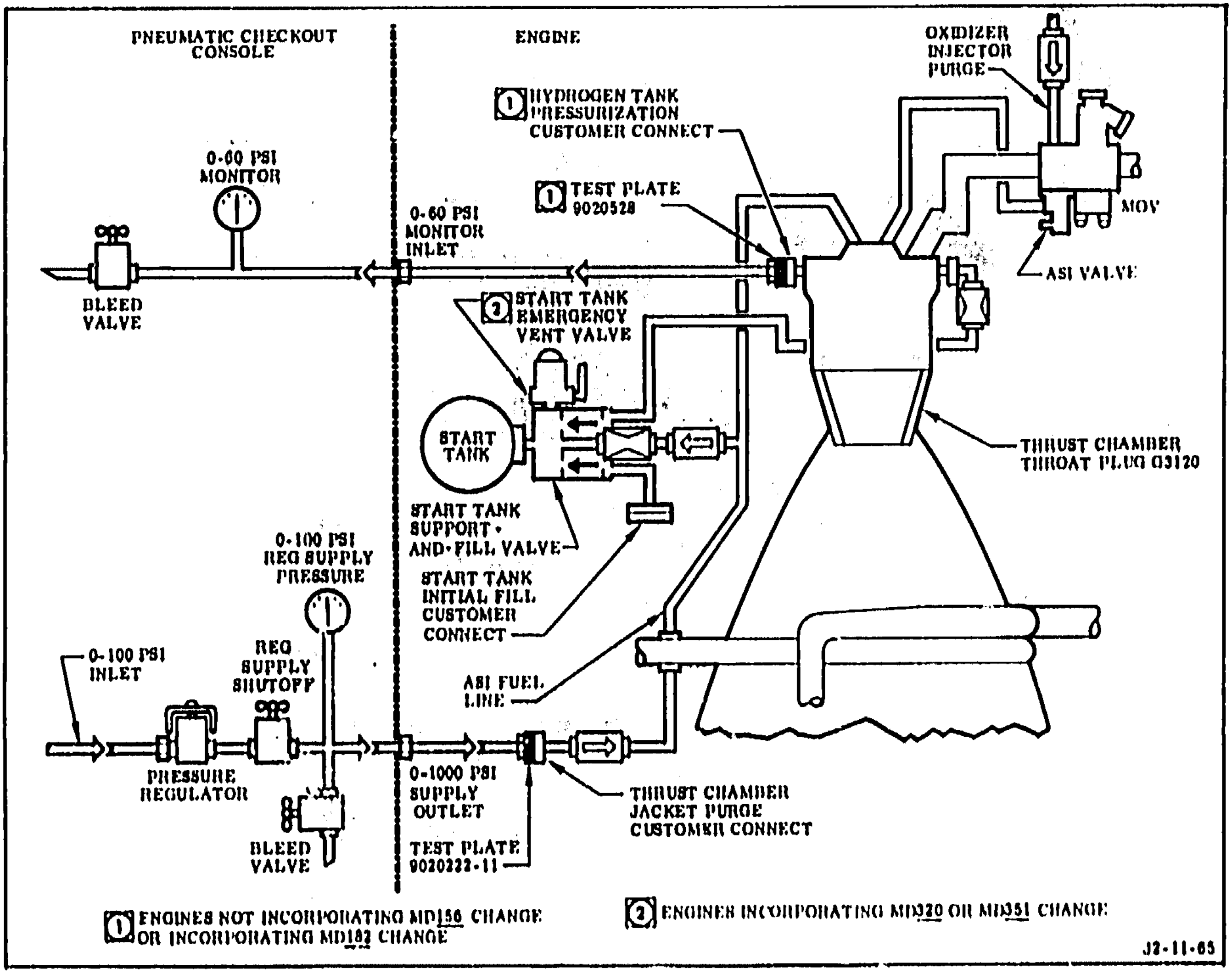


Figure 3-26. Thrust Chamber Assembly Test Setup

c. Remove exhaust system test plates as outlined in paragraph 3.2.3 unless a thrust chamber test is to be performed on an engine incorporating MD166 change but not incorporating MD301, MD302, MD322, or MD323 change.

d. Secure pneumatic checkout console and pneumatic flowtester (paragraphs 3.2.30.4 and 3.2.30.5).

e. Reinstall threaded plugs and torque to 22-28 in-lb.

3.2.27 TESTING THRUST CHAMBER. This test consists of pressurizing the thrust chamber and leak-testing all flanges, bosses, and connections in the pressurized systems. See figure 3-2 for customer connect locations; see figure 3-26 for thrust chamber test setup. Refer to section II for checkout constraints before performing this test. The following test equipment is required:

a. Pneumatic Flow Tester G3104.

b. Pneumatic Checkout Console G3106.

c. Thrust Chamber Throat Plug Kit G3120MD3.

d. Thrust chamber protective pad 9016705.

e. Electrical Checkout Console G1037.

f. Test plate 9020222-11 (kit 9018843-11).

g. Test plate 9020223 (kit 9016724).

h. On engines not incorporating MD156 change or incorporating MD182 change, test plate 9020528 (kit 9020266).

i. Test adapter 9025818 (adapter kit 9025817).

j. Test plate 9019858 (kit 9016713).

jA. Test plate 9020275 (kit 9017274).

k. The following exhaust system test plates and equipment:

(1) Test plate 9019860-11 (kit 9016710-11).

(2) Test plate 9020251-11 (kit 9016723-11).

(3) Adapter 9022823 (adapter kit 9018846).

(4) Heat exchanger handler 9016790-11.

(5) Bypass valve removal tool 9020269.

(6) Duct flange brackets 9021015 and 9021016.

(7) Test plate 9020225 (kit 9016701-11).

3.2.27.1 Preparing for Test.

a. Remove thrust chamber exit closure.

b. Remove protective closure from purge control valve vent line (at thrust chamber exit).

c. Install thrust chamber protective pad 9016705 in thrust chamber.

d. Install Presstite tape, Type 587.3 (Interchemical Corp), and cover with 2-inch-wide Teflon Temp-R-Tape, Type C (Connecticut Hard Rubber Co), in thrust chamber throat plug seating area as follows:

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

(1) Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe a 4-inch portion of thrust chamber throat approximately 9 inches down from injector face or approximately 4 inches from throat.

(2) Cut two 28 ±1 inch pieces of 1/2-inch-wide Presstite tape.

(3) Cover Presstite tape with Teflon Temp-R-Tape. Press tape slightly to make sure tape sticks to Presstite tape.

(4) Remove paper backing from the 2 strips of tape, and install tape around inside of thrust chamber throat approximately 11 inches from face of injector or approximately 6 inches from throat. Trim ends, as necessary, to make one continuous band of tape; make sure tape ends are pressed firmly together. Press tape slightly with fingers, as required, to make tape stay in place.

(5) Cut a 4-inch piece of Presstite tape. Place tape on workbench with paper backing facing workbench. Cut tape into 2 pieces 1/4-inch wide by 4 inches in length.

(6) Place throat plug half that contains burst diaphragm, on workbench with flat up. Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe flat.

(7) Install the two 4-inch pieces of tape on flat of throat plug. Stretch each piece to width of flat, and install on each side of hole to form 2 seals on flat. Cover each piece of Presstite tape with Teflon Temp-R-Tape. Press tape slightly with fingers, as required, to make tape stay in place. Trim ends of tape at each end flush with edge of flat.

e. Place hand screw in throat plug in stored condition to prevent movement when installing plug.

f. Install half of throat plug into thrust chamber combustion area with handle-equipped end facing thrust chamber exit. Make sure throat plug half does not disturb tape.

g. Install other half of throat plug, and mate plug halves together. Make sure tape strips on flat stay in place during plug installation.

h. Grasp handles and pull sections together toward throat area until a tight fit is obtained.

i. Install test plate 9020222-11 on THRUST CHAMBER JACKET PURGE customer connect. Torque nuts to 61-75 in-lb.

NOTE

MD156 change removes HYDROGEN TANK PRESSURIZATION line and MD182 change reinstalls line.

j. On engines not incorporating MD156 change and on engines incorporating MD182 change, install test plate 9020528 on HYDROGEN TANK PRESSURIZATION customer connect. Torque nuts to 61-75 in-lb. Connect a pressure hose from test plate to 0-60 PSI MONITOR INLET of pneumatic checkout console.

k. On engines incorporating MD156 change, connect a pressure hose from fitting on thrust chamber throat plug to 0-60 PSI MONITOR INLET of pneumatic checkout console.

l. Connect a pneumatic hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console to test plate 9020222-11.

m. Prepare Pneumatic Checkout Console G3106, Electrical Checkout Console G1037, and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.2, 3.2.1.4, and 3.2.1.5).

n. On engines incorporating MD383 or MD384 change, remove plug from oxidizer injector pressure tap CN1.

CAUTION

The brass tube on the side of the plate seal at the leak-detection port must not be removed. (This tube looks like a leak-detection-port brass plug.)

o. Remove plastic cap on tube at leak-detection port at start-tank liquid refill line flange on ASI fuel line (F50). Reinstall cap after test.

3.2.27.2 Leak Testing. (See figure 3-27 for thrust chamber leak-test point locations.)

a. Adjust facility pneumatic pressure to pneumatic checkout console to 50 psig minimum.

b. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

c. Close BLEED valve on PNEUMATIC MONITOR PANEL (0-60).

CAUTION

Pressure indicated on the monitor gage must not exceed 35 psi anytime the thrust chamber is pressurized.

d. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until pressure gage on PNEUMATIC MONITOR PANEL (0-60) indicates 30 ±5 psi.

NOTE

Minor leakage around the throat plug is allowable.

Operation	Result
e. Using pneumatic flowtester or leak-test compound, as applicable, leak-test applicable connections and lines on thrust chamber assembly.	Leakage is not allowable unless otherwise noted in figure 3-27.
f. Using leak detector, test braided sections of system under test.	Leakage is not allowable.

Leak-Test Point Description	Location Code in Figure 3-32	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
ASI valve connection to ASI oxidizer line	L32	X	
MOV downstream flange	L33	X	
Main oxidizer injector pressure instrumentation port CO3	L34	X	
CO3 line to auxiliary FI package			X
Flange seal between ASI injector and thrust chamber injector	L35	X	
Main oxidizer injection pressure instrumentation port CO3a	L36	X	
Mainstage OK pressure switch No. 1	L37	X	
Mainstage OK pressure switch No. 2	L38	X	
Thrust chamber pressure instrumentation port CG1	G12	X	
CG1 line to primary FI package			X
CG1 line from tee to static-test transducer			X
Thrust chamber pressure instrumentation port CG1a	G13		X
CG1a line to static-test transducer			X
Ignition detector probe flange	G14	X	
Main fuel injection pressure instrumentation port CF2	F23	X	
CF2 line to auxiliary FI package			X
CF2 line to static-test transducer "CF2a" (b)			X
Main fuel injection pressure instrumentation port CF2a	F24		X

(b) Engines incorporating MD237 change.

Figure 3-27. Thrust Chamber Assembly Leak-Test Points (Sheet 1 of 3)

(19)

Leak-Test Point Description	Location Code in Figure 3-32	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
CF2a line to dummy transducer "CF2a"[(c)]			X
Thrust chamber forward fuel manifold drain port	F25	X	
Drain port on thrust chamber forward fuel manifold	F26	X	
ASI fuel injection temperature transducer port (acceptance) IFT1[(d)]	F27	X	
ASI fuel injection instrumentation pressure port IF2[(b)(d)]	F28	X	
ASI fuel line connection to ASI fuel manifold[(d)]	F29	X	
Upper and lower ASI fuel line flange connection[(e)]	F49	X	
Start tank liquid refill line flange on ASI fuel line[(e)]	F50	X	
Start tank liquid refill line from ASI fuel line to start tank support-and-fill valve[(f)]			X
Thrust chamber injector connection to thrust chamber forward fuel manifold	F30	X	
Main fuel injection temperature transducer probe CFT2	F31	X	
Hydrogen tapoff (tank pressurization) line pressure instrumentation port HF2[(g)(h)]	F32	X	
Hydrogen tank pressurization line connection to forward fuel manifold[(g)]	F33	X	
Hydrogen tapoff tank pressurization flange plate[(i)]	F33	X	

(b) Engines incorporating MD237 change.
(c) Engines not incorporating MD237 change.
(d) Engines not incorporating MD327, MD328, MD329, MD332, or MD344 change.
(e) Engines incorporating MD327, MD328, MD329, MD332, or MD344 change.
(f) Engines incorporating MD331 or MD344 change but not incorporating MD347 change.
(g) Engines not incorporating MD156 change but incorporating MD182 change.
(h) Engines not incorporating MD200 change.
(i) Engines incorporating MD156 change but not incorporating MD182 change.

Figure 3-27. Thrust Chamber Assembly Leak-Test Points (Sheet 2 of 3)

Leak-Test Point Description	Location Code in Figure 3-32	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
Start tank gaseous (hydrogen) refill line connection to forward fuel manifold	F34	X	
Start tank gaseous refill line to start tank support and fill valve(j)	F35		X
Thrust chamber fuel inlet manifold drain port	F36	X	
ASI fuel line connection to thrust chamber fuel inlet manifold	F37	X	
Fuel inlet manifold drain port	F38	X	
Thrust chamber jacket purge line and fuel jacket purge check valve connection to fuel inlet manifold	F39	X	
Thrust chamber jacket purge line to check valve (upstream side)			X
Thrust chamber fuel inlet manifold pressure instrumentation port CF1	F40	X	
MFV downstream flange	F41	X	
Main fuel injection temperature transducer CFT2a(k)	F51	X	
Oxidizer injector purge check valve connection to MOV	P36	X	

(j) Engines not incorporating MD264 or MD347 change.
(k) Engines not incorporating MD202 change.

Figure 3-27. Thrust Chamber Assembly Leak-Test Points (Sheet 3 of 3)

Operation	Result
g. Using pneumatic flowtester, measure leakage at purge control valve vent line exit or, on engines incorporating MD383 or MD384 change, at pressure tap CN1. Record actual value as oxidizer dome purge check valve reverse leakage.	Maximum allowable leakage is 80 scim.
h. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise. Make sure pressure gage on PNEUMATIC MONITOR PANEL (0-60) remains at 30 ±5 psi.	REG SUPPLY PRESSURE gage indicates zero.

i. Disconnect pressure hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console and test plate 0020222-11 installed at THRUST CHAMBER JACKET PURGE customer connect.

Operation	Result
j. Using pneumatic flowtester, measure leakage at THRUST CHAMBER JACKET PURGE customer connect. Record actual value as fuel jacket purge check valve reverse leakage.	Maximum allowable leakage is 100 scim.
k. Open BLEED valve on PNEUMATIC MONITOR PANEL (0-60).	Pressure gage indicates zero.

NOTE

Steps l through ap apply to engines incorporating MD166 (ECP J2-388) change but not incorporating MD301, MD302, MD322, or MD323 change.

l. Close BLEED valve on PNEUMATIC MONITOR PANEL (0-60) and PNEUMATIC MONITOR PANEL (0-600).

m. Reconnect vent line to purge control valve, and torque bolts to 41-45 in-lb.

n. Install exhaust system test plates in accordance with paragraph 3.2.2 (if not already installed from preceding test).

CAUTION

Bolts specified in step o must be used to prevent galling of duct threaded inserts.

o. Using bolts RD111-1010-3016 (new bolts or bolts recoated with dry-film lubricant), install test plate 9019858 on oxidizer inlet duct. Torque bolts to 190-210 in-lb. Connect test hose from 0-600 PSI MONITOR INLET to test plate, and cap other test plate fitting.

p. Connect test hose from 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console to test adapter 9022823 on fuel turbopump torque access, or install vent adapter on adapter 9022823.

q. Install test adapter 9025818 on exit end of oxidizer turbopump primary seal drain line, and connect a pneumatic hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console to adapter. Torque hose clamp on adapter to 42-45 in-lb.

r. Install test plate 9020275 on HELIUM TANK FILL customer connect. Torque nuts to 61-75 in-lb.

s. Connect a pressure hose between 0-3000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate installed on HELIUM TANK FILL customer connect.

t. Remove protective closures from oxidizer turbopump intermediate seal purge check valve vent line exit and oxidizer turbine seal drain line.

Operation	Result
u. Position PRE-VALVES switch to CLOSED and FACILITY READY switch to READY on engine SIMULATOR panel.	FACILITY READY light on ENGINE CONTROL panel comes on.

v. Position TEST/FIRE select switch on GROUND RELAY panel to OK TO TEST.

w. Position test selector switch on ENGINE TEST/MONITOR panel to COMPONENT TEST.

x. Turn ENGINE GROUND POWER switch on ENGINE CONTROL panel to ON.	(1) The following lights on ENGINE CONTROL panel come on: (a) ENGINE GROUND POWER. (b) MAINSTAGE OK NO. 1 DEPRESSURIZED.

i. Disconnect pressure hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console and test plate 9020222-11 installed at THRUST CHAMBER JACKET PURGE customer connect.

Operation	Result
j. Using pneumatic flowtester, measure leakage at THRUST CHAMBER JACKET PURGE customer connect. Record actual value as fuel jacket purge check valve reverse leakage.	Maximum allowable leakage is 100 scim.
k. Open BLEED valve on PNEUMATIC MONITOR PANEL (0-60).	Pressure gage indicates zero.

NOTE

Steps l through ap apply to engines incorporating MD166 (ECP J2-388) change but not incorporating MD201, MD302, MD322, or MD323 change.

l. Close BLEED valve on PNEUMATIC MONITOR PANEL (0-60) and PNEUMATIC MONITOR PANEL (0-600).

m. Reconnect vent line to purge control valve, and torque bolts to 41-45 in-lb.

n. Install exhaust system test plates in accordance with paragraph 3.2.2 (if not already installed from preceding test).

CAUTION

Bolts specified in step o must be used to prevent galling of duct threaded inserts.

o. Using bolts RD111-1010-3016 (new bolts or bolts recoated with dry-film lubricant), install test plate 9019858 on oxidizer inlet duct. Torque bolts to 190-210 in-lb. Connect test hose from 0-600 PSI MONITOR INLET to test plate, and cap other test plate fitting.

p. Connect test hose from 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console to test adapter 9022823 on fuel turbopump torque access, or install vent adapter on adapter 9022823.

q. Install test adapter 9025818 on exit end of oxidizer turbopump primary seal drain line, and connect a pneumatic hose from 0-100 PSI SUPPLY OUTLET of pneumatic checkout console to adapter. Torque hose clamp on adapter to 42-45 in-lb.

r. Install test plate 9020275 on HELIUM TANK FILL customer connect. Torque nuts to 61-75 in-lb.

s. Connect a pressure hose between 0-3000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate installed on HELIUM TANK FILL customer connect.

t. Remove protective closures from oxidizer turbopump intermediate seal purge check valve vent line exit and oxidizer turbine seal drain line.

Operation	Result
u. Position PREVALVES switch to CLOSED and FACILITY READY switch to READY on engine SIMULATOR panel.	FACILITY READY light on ENGINE CONTROL panel comes on.
v. Position TEST/FIRE select switch on GROUND RELAY panel to OK TO TEST.	
w. Position test selector switch on ENGINE TEST/MONITOR panel to COMPONENT TEST.	
x. Turn ENGINE GROUND POWER switch on ENGINE CONTROL panel to ON.	(1) The following lights on ENGINE CONTROL panel come on: (a) ENGINE GROUND POWER. (b) MAINSTAGE OK NO. 1 DEPRESSURIZED.

Operation	Result
	(c) MAINSTAGE OK NO. 2 DEPRESSURIZED. (d) TEST. (2) The following lights on ENGINE/TEST MONITOR panel come on: (a) COMPONENT TEST. (b) IGNITION BUS ARMED. (c) On engines incorporating ECA 502670-111, or -211, START TANK PRESSURIZED and START TANK DEPRESSURIZED.
y. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-1000).	
z. Position HELIUM CONTROL, IGNITION PHASE CONTROL, and MAINSTAGE CONTROL switches on ENGINE TEST/MONITOR panel to ON.	HELIUM CONTROL, IGNITION PHASE CONTROL, and MAINSTAGE CONTROL lights come on.
aa. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until REG SUPPLY PRESSURE gage indicates 225-250 psi.	
ab. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until pressure gage indicates 30 ±1 psi.	
ac. Using leak-test compound, leak-test joints and connections of oxidizer pump seal drain line and purge control valve vent line from valve to tee in drain line.	Leakage is not allowable.
ad. Using leak-test compound, leak-test connections of oxidizer turbopump primary seal pressure (PO6) instrumentation line from turbopump to auxiliary FI package and from tee to static-test transducer.	Leakage is not allowable.
ae. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise.	REG SUPPLY PRESSURE gage indicates zero.
af. Open BLEED valve on PNEUMATIC MONITOR PANEL (0-60), PNEUMATIC MONITOR PANEL (0-600), and 0-1000 PSI SUPPLY OUTLET (or open vent adapter, as applicable).	Monitor and supply pressure gages indicate zero.
ag. Position IGNITION PHASE CONTROL and MAINSTAGE CONTROL switches on ENGINE/TEST MONITOR panel to OFF.	IGNITION PHASE CONTROL and MAINSTAGE CONTROL lights go off.
ah. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.	
ai. After all pressure has vented from pneumatic control system and helium tank, position HELIUM CONTROL switch on ENGINE/TEST MONITOR panel to OFF.	HELIUM CONTROL light goes off.
aj. Position the following switches on electrical checkout console to OFF: (1) Test selector on ENGINE TEST/MONITOR panel.	All lights on electrical checkout console go off.

Operation	Result

(2) TEST/FIRE SELECT on GROUND RELAY panel.

(3) ENGINE GROUND POWER on ENGINE CONTROL panel.

ak. Position FACILITY READY switch on SIMULATOR panel to NOT READY.

al. Disconnect pressure hose from 0-3000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate installed on HELIUM TANK FILL customer connect.

am. Remove test plate from HELIUM TANK FILL customer connect.

an. Install protective closure on vent line exit and oxidizer primary and turbine seal drain lines.

ao. Disconnect pneumatic hoses installed for this test, and disconnect vent adapter on adapter 9022823 on fuel torque access. Remove adapter from drain line exit of oxidizer primary seal drain line, and remove test plate 9019858 from oxidizer inlet duct.

ap. On engines incorporating MD156 change, disconnect pressure hose from 0-60 PSI MONITOR INLET of pneumatic checkout console and fitting on thrust chamber throat plug.

aq. Remove throat plug as follows:

(1) Rotate hand screw in throat plug until upper portion of throat plug slides forward. Place hand screw in stored position.

(2) Push throat plug into combustion area.

(3) Rotate upper half of throat plug and disengage from pivot.

(4) Remove throat plug sections from thrust chamber.

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

ar. Remove tape from thrust chamber throat and throat plug. Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe throat area where tape was installed, to make sure area is clean.

as. Remove thrust chamber protective pad.

at. If exhaust system test plates were installed for this test, remove plates in accordance with paragraph 3.2.3.

au. If start system leak test is to follow, or on engines incorporating MD254 or MD347 change, proceed to paragraph 3.2.27.3.

av. Install test plate 9020223 on START TANK VENT VALVE CONTROL customer connect. Torque nuts to 61-75 in-lb.

aw. Install a pneumatic hose from 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console to test plate 9020223.

ax. Remove protective cover from START TANK VENT & RELIEF VALVE DRAIN customer connect.

ay. Vent pressure in start tank by turning PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until pressure gage indicates 250 psi maximum.

az. When all pressure is vented from start tank, close REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-1000).

ba. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) fully counterclockwise until pressure gage indicates zero.

3.2.27.3 Securing After Test. If another test is to be performed, the removal of test equipment required for that test may be disregarded.

a. Install thrust chamber exit closure.

b. Install protective closure on purge control valve vent line if closure was removed for this test.

c. Disconnect the following test hoses from pneumatic checkout console and engine:

NOTE

MD156 change removes the HYDROGEN TANK PRESSURIZATION line and MD182 change reinstalls the line.

(1) On engines not incorporating MD156 change and on engines incorporating MD182 change, 0-60 PSI MONITOR INLET of pneumatic checkout console and plate 9020528 on HYDROGEN TANK PRESSURIZATION customer connect.

(2) 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate 9020223 installed on START TANK VENT VALVE CONTROL customer connect.

d. Remove test plate from THRUST CHAMBER JACKET PURGE customer connect. Install protective cover on customer connect.

NOTE

MD156 change removes the HYDROGEN TANK PRESSURIZATION line and MD182 change reinstalls the line.

e. On engines not incorporating MD156 change and on engines incorporating MD182 change, remove test plate from HYDROGEN TANK PRESSURIZATION customer connect. Install protective closure on customer connect.

f. Remove test plate from START TANK VENT VALVE CONTROL customer connect. Install protective closure on customer connect and on START TANK VENT & RELIEF VALVE DRAIN customer connect.

fA. On engines incorporating MD383 or MD384 change, install new seal and reinstall plug in pressure tap CN1. Torque plug to 66-73 in-lb and safetywire.

g. Secure electrical checkout console, pneumatic checkout console, and pneumatic flow tester (paragraphs 3.2.30.2, 3.2.30.4, and 3.2.30.5).

3.2.28 TESTING CUSTOMER-CONNECT LINES. This test consists of pressurizing and leak-testing the oxidizer tank pressurization and start tank and relief valve drain lines, which are customer connect lines. See figure 3-2 for customer connect locations. See figure 3-28 for customer-connect test setup. See figure 3-32 for leak-test point location. Refer to section II for checkout constraints before performing this test. The following test equipment is required:

a. Pneumatic Flow Tester G3104.

b. Pneumatic Checkout Console G3106.

c. On engines incorporating MD105 change, test plate 9016746 (kit 9016719).

d. Test plate 9020222-11 (kit 9018843-11).

e. Test plate 9020528 (kit 9020266).

3.2.28.1 Preparing for Test.

a. Prepare Pneumatic Checkout Console G3106 and Pneumatic Flow Tester G3104 (paragraphs 3.2.1.4 and 3.2.1.5).

b. Install test plate 9020528 on OXIDIZER TANK PRESSURIZATION customer connect. Torque nuts to 61-75 in-lb.

c. On engines incorporating MD105 or MD194 change, install test plate 9016746 on HEAT EXCHANGER HELIUM INLET customer connect. Torque nuts to 61-75 in-lb. Make sure that pressure cap is on inlet connection.

d. Install test plate 9020222-11 on START TANK VENT & RELIEF VALVE DRAIN customer connect. Torque nuts to 61-75 in-lb.

e. Adjust facility pneumatic pressure to pneumatic checkout console to 100 psig minimum.

3.2.28.2 Leak-Testing Oxidizer Tank Pressurization Line.

a. Connect pneumatic hose between 0-100 PSI SUPPLY OUTLET of pneumatic checkout console and test plate 9020528 installed on OXIDIZER TANK PRESSURIZATION customer connect.

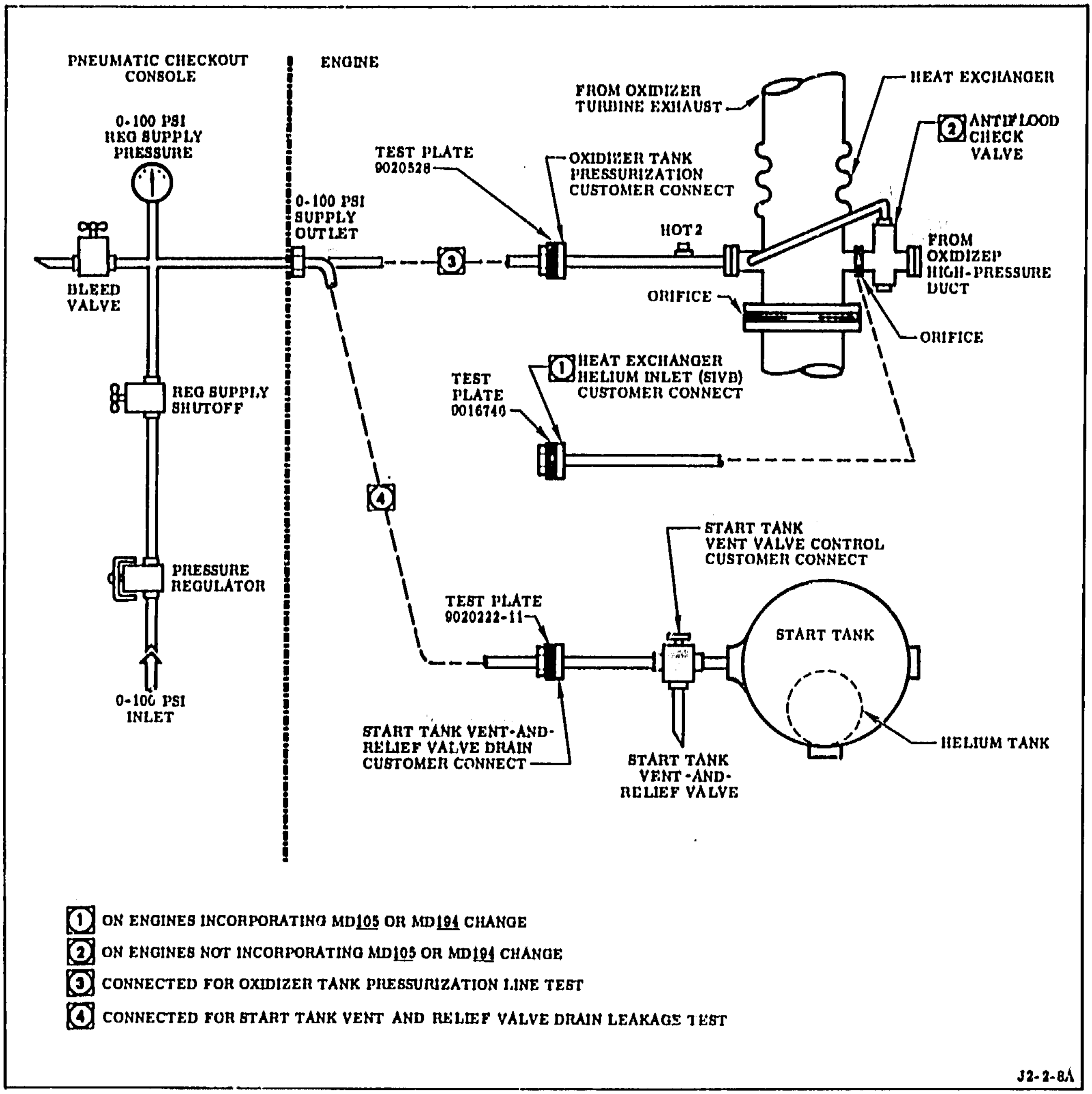


Figure 3-28. Customer Connect Leak-Test Setup

b. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

c. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±5 psi.

Operation	Result
d. On engines not incorporating MD105 or MD194 change, leak-test oxidizer tank pressurization line and the following leak-test points:	Leakage is not allowable.
(1) Heat exchanger antiflood check valve connection to heat exchanger (L24).	

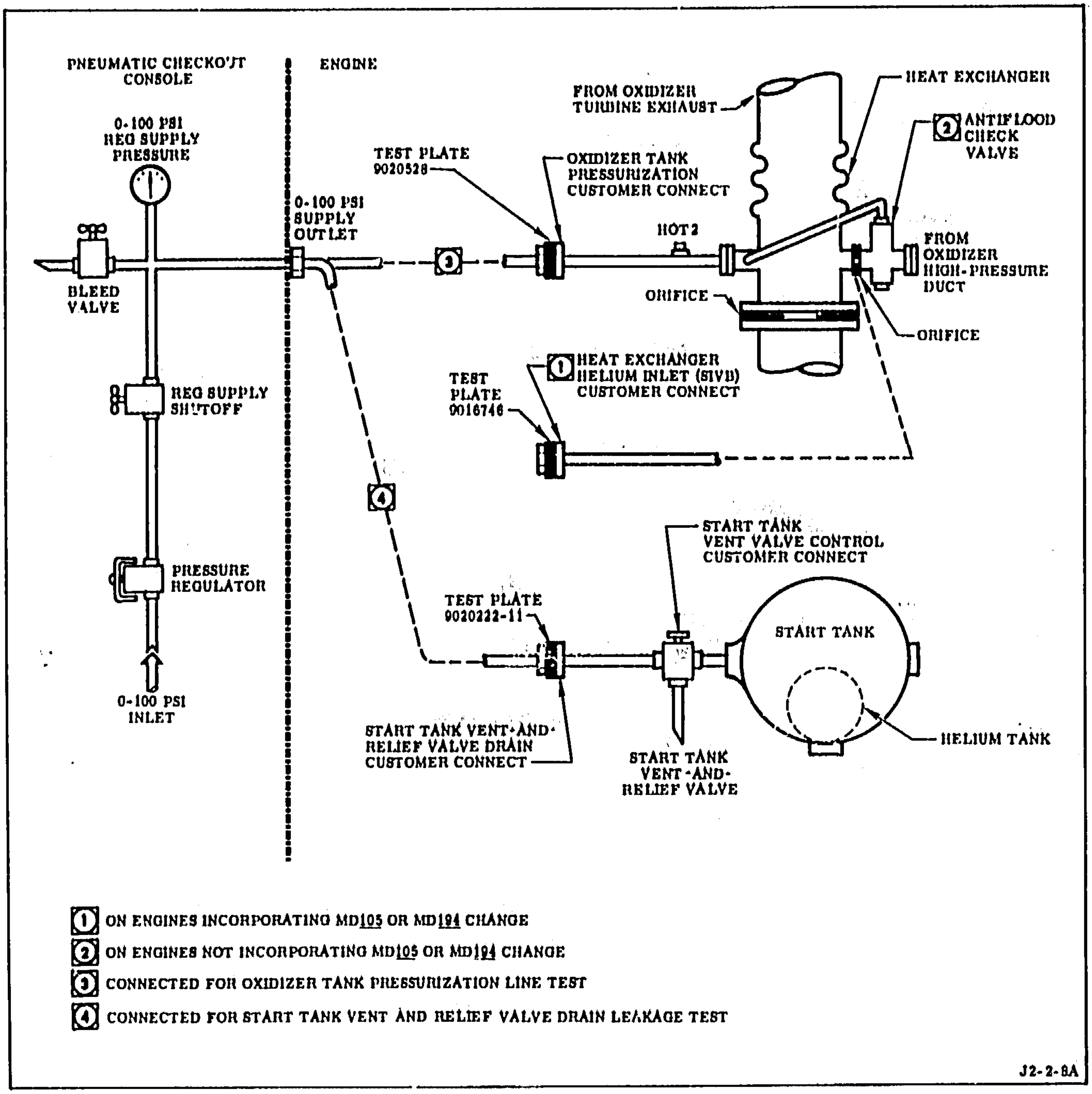


Figure 3-28. Customer Connect Leak-Test Setup

b. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

c. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 30 ±5 psi.

Operation	Result
d. On engines not incorporating MD105 or MD194 change, leak-test oxidizer tank pressurization line and the following leak-test points:	Leakage is not allowable.
(1) Heat exchanger antiflood check valve connection to heat exchanger (L24).	

Operation	Result
(2) Bypass line flange connection to antiflood check valve (L25).	
(3) Heat exchanger outlet flange (L26).	
(4) Heat exchanger outlet temperature transducer HOT2 (L27).	
e. On engines incorporating MD105 or MD194 change, leak-test oxidizer tank pressurization line, helium inlet line, and the following leak-test points:	Leakage is not allowable.
(1) Helium inlet line connection to heat exchanger (L24).	
(2) Bypass line flange blank plate (L25).	
(3) Heat exchanger outlet flange (L26).	
(4) Plate on oxidizer tank pressurization line over transducer mounting port (L27).	

f. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

g. Disconnect pneumatic hose from OXIDIZER TANK PRESSURIZATION customer connect.

3.2.28.3 Leak-Testing Start Tank Vent-and-Relief Valve Drain Line.

a. Connect pneumatic hose between 0-100 PSI SUPPLY OUTLET on pneumatic checkout console and test plate 9020222-11 installed on START TANK VENT & RELIEF VALVE DRAIN customer connect.

b. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-100).

CAUTION

Pressure exceeding 30 psig can damage the start tank vent-and-relief valve diaphragm.

c. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) to INCREASE until REG SUPPLY PRESSURE gage indicates 28-30 psi. Do not exceed 30 psig during this test.

Operation	Result
d. Leak-test all flanges and connections in drain line from test plate to start tank vent-and-relief valve.	Leakage is not allowable.
e. Using leak-detector, leak-test braided sections of system under test.	Leakage is not allowable.

f. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-100) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

g. Disconnect pneumatic hose from test plate and 0-100 PSI SUPPLY OUTLET on pneumatic checkout console.

3.2.28.4 Securing After Test. If another test is to be performed, removal of test equipment required for that test may be disregarded.

a. Remove test plates from engine customer connects and install protective covers.

b. Secure pneumatic checkout console and pneumatic flowtester (paragraphs 3.2.30.4 and 3.2.30.5).

3.2.29 TESTING ENGINE SEQUENCE. This test consists of supplying pressure to the engine pneumatic control system and operating the engine electrical control system. The engine valve

and timer operations are recorded on test equipment. See figure 3-29 for recorder and oscillograph assignments, figure 1-8 for valve operating times, and figure 3-30 for timer operating times. Refer to section II for checkout constraints before performing this test. The following test equipment is required:

a. Flight Instrumentation Checkout Console G1035.

b. Electrical Checkout Console G1037.

c. Pneumatic Flow Tester G3104.

d. Pneumatic Checkout Console G3106.

e. Data Recorder Console G3121.

f. Test plate 9020223 (kit 9016724).

g. Test plate 9020275 (kit 9017274).

h. Redundant timer adapter assembly EWR220289.

3.2.20.1 Preparing for Test.

a. Connect engine and all checkout equipment (figure 3-1).

b. Prepare Flight Instrumentation Checkout Console G1035, Electrical Checkout Console G1037, Data Recorder Console G3121, Pneumatic Flow Tester G3104, and Pneumatic Checkout Console G3106 (paragraphs 3.2.1.1 through 3.2.1.5).

c. Adjust facility pneumatic pressure to pneumatic checkout console to 1,600 psig minimum.

CAUTION

If the start tank is pressurized during test, start tank pressure will spin the turbopump causing damage to equipment.

d. To make sure that start tank is not pressurized, perform steps e through m.

e. Install test plate 9020223 on START TANK VENT VALVE CONTROL customer connect.

f. Connect a pneumatic hose between 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate 9020223 on START TANK VENT VALVE CONTROL customer connect.

g. Remove closure from START TANK VENT & RELIEF VALVE DRAIN customer connect.

h. Close BLEED valve and open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-1000).

WARNING

Failure to observe the safety requirements of step i can result in injury to personnel.

Operation	Result
i. Clear personnel from area of START TANK VENT & RELIEF VALVE DRAIN customer connect; then turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) to INCREASE until REG SUPPLY PRESSURE gage indicates 250 psi maximum.	Any pressure in start tank must vent through START TANK VENT & RELIEF VALVE DRAIN customer connect.

j. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-1000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

k. Disconnect pneumatic hose from 0-1000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate 9020223 on START TANK VENT VALVE CONTROL customer connect, and install pressure cap on 0-1000 PSI SUPPLY OUTLET.

l. Remove test plate from START TANK VENT VALVE CONTROL customer connect, and install protective closure.

m. Install closure on START TANK VENT & RELIEF VALVE DRAIN customer connect.

n. Install test plate 9020275 at HELIUM TANK FILL customer connect. Torque nuts to 61-75 in-lb.

o. Install a pressure hose between 0-3000 PSI SUPPLY OUTLET of pneumatic checkout console and test plate at HELIUM TANK FILL customer connect.

p. Remove protective cover from oxidizer turbopump turbine seal drain line.

q. Remove protective cover from oxidizer turbopump primary seal drain line (at thrust chamber exit), or on engines incorporating MD301, MD302, MD322, or MD323 change, remove cover from OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.

r. Remove protective cover from oxidizer turbopump intermediate seal purge check valve vent line exit.

s. Remove thrust chamber exit closure, or open one desiccant access cover on closure.

Recorder Pen No.	Parameter
1	Fuel injection temperature OK
2	Engine ready
3	Engine start
4	Helium control solenoid (energize)
5	Ignition-phase control solenoid (energize)
6	MFV (close)
7	MFV (open)
8	ASI valve (open)
9	STDV control solenoid (energize)
10	STDV (close)
11	STDV (open)
12	Mainstage control solenoid (energize)
13	MOV (close)
14	Spare
15	MOV (open)
16	GG valve (close)
17	GG valve (open)
18	OTBV (close)
19	OTBV (open)
20	Spare
21	Spare
22	Spare
23	No. 1 ASI spark
24	No. 2 ASI spark
25	No. 1 GG spark
26	No. 2 GG spark
27	Start tank pressurized
28	Start tank depressurized
29	Ignition complete
30	No. 1 mainstage OK pressurized
31	No. 2 mainstage OK pressurized
32	No. 1 mainstage OK depressurized
33	No. 2 mainstage OK depressurized
34	Oxidizer bleed valve (close)
35	Fuel bleed valve (close)
36	Observer cutoff
37	Oxidizer turbopump overspeed trip cutoff
38	Fuel turbopump overspeed trip cutoff
39	Engine cutoff (LOCKIN)
40	Engine cutoff (vehicle)
41 through 59	Spares
60	Timer (one-second)

Oscillograph Channel No.	Parameter
1	Multiplex No. 1 (1) Helium control (2) Mainstage control (3) Ignition-phase control (4) Start tank discharge control
2	Multiplex No. 2 (1) Engine start (2) Cutoff (LOCKIN) (3) Ignition complete (4) Mainstage OK No. 1
3	Multiplex No. 3 (1) Temperature OK (2) ASI sparks on (3) GG sparks on (4) Start tank depressurized
4	Multiplex No. 4 (1) Spare (2) Mainstage OK No. 2 (3) Spare (4) Spare
5	No. 1 ASI spark rate
6	No. 2 ASI spark rate
7	No. 1 GG spark rate
8	No. 2 GG spark rate
9	MFV position
10	MOV position
11	GG valve position
12	OTBV position
13	STDV position
14	PU valve position[(a)]
14	MRCV position[(b)]
15	Fuel turbopump speed
16	Oxidizer turbopump speed
17	Fuel turbopump flow
18	Oxidizer turbopump flow

(a) Engines not incorporating MD366 or MD371 change.
(b) Engines incorporating MD366 or MD371 change.

Figure 3-29. Recorder and Oscillograph Assignments

Timer	Timing (Seconds)	Oscillograph (Traces)
Start tank discharge delay	0.640 ±0.030 1.000 ±0.040[a]	Multiplex No. 2 channel 1 to Multiplex No. 1 channel 4
Ignition phase	0.450 ±0.030	Multiplex No. 1 channel 4 to Multiplex No. 1 channel 2
Sparks deenergize	3.30 ±0.200	Multiplex No. 1 channel 2 to Multiplex No. 3 channel 2
Helium control deenergize	1.00 ±0.110	Multiplex No. 2 channel 2 to Multiplex No. 1 channel 1

(a) Engines incorporating MD205 change.

Figure 3-30. Timer Operating Times

3.2.29.2 Sequence Testing.

WARNING

Failure to observe the safety requirements of step a can result in injury to personnel.

a. Clear area of personnel. Personnel must stand behind adequate safety barriers or at a safe distance from engine.

b. Close BLEED valve on PNEUMATIC SUPPLY PANEL (0-3000).

c. Open REG SUPPLY SHUTOFF valve on PNEUMATIC SUPPLY PANEL (0-3000).

d. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) to INCREASE until REG SUPPLY PRESSURE gage indicates 1,400-1,600 psi.

Operation	Result
e. Position switches on electrical checkout console as follows:	
(1) Test selector on ENGINE TEST/MONITOR panel to SEQUENCE TEST.	
(2) FACILITY READY on engine SIMULATOR panel to READY.	FACILITY READY light on ENGINE CONTROL panel comes on.
(3) PREVALVES on engine SIMULATOR panel to CLOSED.	
(4) TEST/FIRE SELECT on GROUND RELAY panel to OK TO TEST.	
(5) MAINSTAGE OK BYPASS on ENGINE TEST/MONITOR panel to ON.	
(6) IGNITION COMPLETE BYPASS on ENGINE TEST/MONITOR panel to ON.	
(7) On engines incorporating ECA 502670-211, FUEL INJECTION TEMPERATURE OK on ENGINE TEST/MONITOR panel to OFF; on engines incorporating MD204 change or not incorporating ECA 502670-211, to TEMP DETECTOR BYPASS.	

Operation	Result
(8) IGNITION BUS ARMED on ENGINE TEST/MONITOR panel to ARMED.	
(9) Switch below EMERG START TANK VENT light on ENGINE CONTROL panel to CLOSED.	
(10) EMERG HELIUM TANK VENT on ENGINE CONTROL panel to OFF.	
f. Position ENGINE GROUND POWER switch on ENGINE CONTROL panel to ON.	(1) ENGINE BUS VOLTAGE meter indicates 24-30 vdc. (2) The following lights on ENGINE TEST/MONITOR panel come on: (a) MAINSTAGE OK. (b) SEQUENCE TEST. (c) IGNITION BUS ARMED. (d) On engines incorporating ECA 502670-211, START TANK PRESSURIZED and START TANK DEPRESSURIZED. (3) The following lights on ENGINE CONTROL panel come on: (a) ENGINE GROUND POWER. (b) TEST. (c) MAINSTAGE OK NO. 1 DEPRESSURIZED. (d) MAINSTAGE OK NO. 2 DEPRESSURIZED. (e) MAINSTAGE OK NO. 1 PRESSURIZED. (f) MAINSTAGE OK NO. 2 PRESSURIZED. (g) If IGNITION COMPLETE light comes on, there is a malfunction; do not continue with test until trouble is corrected.

g. During remainder of this procedure, disregard all lights not specified in procedure.

Operation	Result
gA. On engines incorporating MD366 or MD371 change, position MRC VALVE switch on ENGINE TEST/MONITOR panel to OPEN.	MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel comes on.

h. On engines incorporating MD204 change or not incorporating ECA 502670-211, proceed to step o. (Steps i through n apply to engines incorporating ECA 502670-211.)

Operation	Result
i. Momentarily press ENGINE START button on ENGINE CONTROL panel.	(1) Engine sequence starts. (2) After IGNITION COMPLETE light on ENGINE TEST/MONITOR panel comes on, engine sequence stops.
j. After 7 seconds, position FUEL INJECTION TEMPERATURE OK switch on ENGINE TEST/MONITOR panel to TEMP OK BYPASS.	FUEL INJECTION TEMPERATURE OK light comes on and engine sequence continues.
k. On engines not incorporating MD366 or MD371 change, approximately 6 seconds after the 4 spark lights on ENGINE TEST/MONITOR panel go off, momentarily press CUTOFF knob on ENGINE CONTROL panel.	CUTOFF AND CUTOFF LOCKIN lights on ENGINE CONTROL panel come on.

Operation	Result
kA. On engines incorporating MD366 or MD377 change, perform the following:	
(1) Approximately 5 seconds after the 4 spark lights on ENGINE TEST/MONITOR panel go off, position MRC VALVE switch to CLOSED.	MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel goes off.
(2) Position MRC VALVE switch on ENGINE TEST/MONITOR panel to OPEN.	MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel comes on.
(3) Momentarily press CUTOFF knob on ENGINE CONTROL panel	CUTOFF and CUTOFF LOCKIN lights on ENGINE CONTROL panel come on.
l. When HELIUM CONTROL light on ENGINE TEST/MONITOR panel goes off, momentarily press CUTOFF RESET button on ENGINE CONTROL panel.	CUTOFF and CUTOFF LOCKIN lights on ENGINE CONTROL panel and CUTOFF light on GROUND RELAY panel go off.

m. Wait 5 minutes before proceeding to next step.

n. Position FUEL INJECTION TEMPERATURE OK switch on ENGINE TEST/MONITOR panel to TEMP DETECTOR BYPASS. Repeat steps l and k through m, then proceed to step p.

NOTE

Steps o through pB apply to engines incorporating MD204 change.

Operation	Result
o. Momentarily press ENGINE START button on ENGINE CONTROL panel.	Engine sequence starts and continues into mainstage condition.
p. On engines incorporating MD366 or MD371 change, perform the following:	
(1) Approximately 5 seconds after the 4 spark lights on ENGINE TEST/MONITOR panel go off, position MRC VALVE switch to CLOSED.	MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel goes off.
(2) Position MRC VALVE switch on ENGINE TEST/MONITOR panel to OPEN.	MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel comes on.
(3) Momentarily press CUTOFF knob on ENGINE CONTROL panel.	CUTOFF and CUTOFF LOCKIN lights on ENGINE CONTROL panel come on.
pA. On engines not incorporating MD366 or MD371 change, approximately 6 seconds after the 4 spark lights on ENGINE TEST/MONITOR panel go off, momentarily press cutoff knob on ENGINE CONTROL panel.	CUTOFF and CUTOFF LOCKIN lights on ENGINE CONTROL panel come on.

pB. Wait 5 minutes before proceeding to step q.

q. Position switches on data recorder console as follows:

Operation	Result
(1) Event recorder CHARTS SPEEDS to 125.	
(2) Oscillograph POWER TAKE UP REEL to ON.	Light comes on.

r. Start recorders and initiate engine start as follows:

(1) Press oscillograph red ON-OFF button.

NOTE

To prevent excessive use of event recorder and oscillograph paper, substeps 2 through 4 must be performed in rapid sequence.

Operation	Result
(2) Position event recorder POWER switch to ON.	
(3) Press oscillograph chart speed button 16.	
(4) Momentarily press ENGINE START button on ENGINE CONTROL panel.	Engine sequence starts and continues into mainstage condition.

Operation	Result
s. On engines not incorporating MD366 or MD371 change, approximately 6 seconds after the 4 spark lights on ENGINE TEST/MONITOR panel go off, momentarily press CUTOFF knob on ENGINE CONTROL panel.	CUTOFF and CUTOFF LOCKIN lights come on.

sA. On engines incorporating MD366 or MD371 change, perform the following:

Operation	Result
(1) Approximately 5 seconds after the 4 spark lights on ENGINE TEST/MONITOR panel go off, position MRC VALVE switch to CLOSED.	MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel goes off.

(2) Record reading on DIGITAL VOLT-OHMMETER on flight instrumentation panel.

Operation	Result
(3) Position MRC VALVE switch on ENGINE TEST/MONITOR panel to OPEN.	MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel comes on.
(4) Record reading on DIGITAL VOLT-OHMMETER on flight instrumentation checkout console.	On engines incorporating MD371 change, voltage change from substep 2 must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from substep 2 must be between 0.6 and 1.0 vdc.

NOTE

The MRCV closing time is measured from engine cutoff (substep 5) or from helium control valve deenergized (step t). (Refer to figure 1-11 for times.)

Operation	Result
(5) Momentarily press CUTOFF knob on ENGINE CONTROL panel.	CUTOFF and CUTOFF LOCKIN lights come on.
t. When HELIUM CONTROL light on ENGINE TEST/MONITOR panel goes off, position event recorder POWER switch to OFF and press oscillograph red ON-OFF button.	Recorder stops.
u. Momentarily press CUTOFF RESET button on ENGINE CONTROL panel.	CUTOFF and CUTOFF LOCKIN lights on ENGINE CONTROL panel and CUTOFF light on GROUND RELAY panel go off.
uA. On engines incorporating MD366 or MD371 change, approximately 5 seconds after step u, position MRC VALVE switch on ENGINE TEST/MONITOR panel to CLOSED.	MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel goes off.
uB. On engines incorporating MD366 or MD371 change, read DIGITAL VOLT-OHMMETER on flight instrumentation checkout console.	On engines incorporating MD371 change, voltage change from step sA (substep 4) must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step sA (substep 4) must be between 0.6 and 1.0 vdc.

uC. Disconnect cable plug P3 from connector J-3 on SPARK MONITOR PANEL and install redundant timer adapter EWR220289 on cable plug P3.

v. Wait 5 minutes after performing step u; then proceed as follows:

vA. Start recorders and initiate engine start as follows:

(1) Press oscillograph red ON-OFF button.

Operation	Result

NOTE

To prevent excessive use of event recorder and oscillograph paper, substeps 2 through 4 must be performed in rapid sequence.

(2) Position event recorder POWER switch to ON.

(3) Press oscillograph chart speed button 16.

Operation	Result
(4) Momentarily press ENGINE START button on ENGINE CONTROL panel.	Engine sequence starts and continues into mainstage condition.
vB. On engines not incorporating MD366 or MD371 change, approximately 10 seconds after pressing ENGINE START button on ENGINE CONTROL panel, momentarily press CUTOFF knob on ENGINE CONTROL panel.	CUTOFF and CUTOFF LOCKIN lights come on.

vC. On engines incorporating MD366 or MD371 change, perform the following:

Operation	Result
(1) Approximately 10 seconds after pressing ENGINE START button on ENGINE CONTROL panel, position MRC VALVE switch to closed.	MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel goes off.

(2) Record reading on DIGITAL VOLT-OHMMETER on flight instrumentation panel.

Operation	Result
(3) Position MRC VALVE switch on ENGINE TEST/MONITOR panel to OPEN.	MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel comes on.
(4) Record reading on DIGITAL VOLT-OHMMETER on flight instrumentation checkout console.	On engines incorporating MD371 change, voltage change from substep 2 must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from substep 2 must be between 0.6 and 1.0 vdc.

NOTE

The MRCV closing time is measured from engine cutoff (substep 5) or from helium control valve deenergized (step t). (Refer to figure 1-11 for times.)

Operation	Result
(5) Momentarily press CUTOFF knob on ENGINE CONTROL panel.	CUTOFF and CUTOFF LOCKIN lights come on.
vD. When HELIUM CONTROL light on ENGINE TEST/MONITOR panel goes off, position event recorder POWER switch to OFF and press oscillograph red ON-OFF button.	Recorder stops.
vE. Momentarily press CUTOFF RESET button on ENGINE CONTROL panel.	CUTOFF and CUTOFF LOCKIN lights on ENGINE CONTROL panel and CUTOFF light on GROUND RELAY panel go off.
vF. On engines incorporating MD366 or MD371 change, approximately 5 seconds after step vD, position MRC VALVE switch on ENGINE TEST/MONITOR panel to CLOSED.	MRC VALVE ENERGIZED light on ENGINE TEST/MONITOR panel goes off.

Operation	Result
vG. On engines incorporating MD366 or MD371 change, read DIGITAL VOLT-OHM-METER on flight instrumentation checkout console.	On engines incorporating MD371 change, voltage change from step sA (substep 4) must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step sA (substep 4) must be between 0.6 and 1.0 vdc.

NOTE

On engines incorporating MD380 or MD381 change, steps vH, vJ, and vK provide a way to determine helium control deenergize timer operation.

Operation	Result
vH. Press oscillograph red ON-OFF button, and momentarily press CUTOFF knob on ENGINE CONTROL panel.	Oscillograph starts and CUTOFF and CUTOFF LOCKIN lights on ENGINE CONTROL panel and CUTOFF light on GROUND RELAY panel come on.
vJ. After a minimum of 3 seconds, momentarily press CUTOFF RESET button on ENGINE CONTROL panel.	CUTOFF and CUTOFF LOCKIN lights go off.
vK. Press oscillograph red ON-OFF button.	Oscillograph stops.

vL. On engines not incorporating MD172 or MD214 change, determine corrected MOV opening time (second-stage motion) by multiplying recorded valve time by temperature correction factor specified in figure 3-51.

vM. On engines incorporating MD172 or MD214 change, if MOV actuator temperature is greater than 70° F, determine corrected MOV opening time (second-stage motion) by multiplying recorded valve time by temperature correction factor specified in figure 3-51.

vN. On engines incorporating MD172 or MD214 change, if MOV actuator temperature is less than 70° F, determine corrected MOV opening time (second-stage motion) by adding time change specified in figure 3-51A to recorded MOV opening time.

NOTE

On engines incorporating MD265 change, the MOV opening time (second-stage motion) is allowed to vary within a band of 50 milliseconds between sequence tests if the average time falls within the limits of figure 1-11.

vP. On engines incorporating MD265 change, refer to Engine Log Book and obtain all MOV opening times (second-stage motion) since installation of control orifice. Using data obtained from Engine Log Book and from sequence test being run, determine average valve time. This average time must be within envelope of figure 1-12 for engines incorporating MD265 change. The maximum allowable variation between any two sequence tests is 50 milliseconds.

w. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) fully counterclockwise until REG SUPPLY PRESSURE gage indicates zero.

Operation	Result
x. Position test selector switch on ENGINE TEST/MONITOR panel to COMPONENT TEST.	(1) The following lights on ENGINE TEST/MONITOR panel come on: (a) COMPONENT TEST. (b) ENGINE READY. (2) The following lights on ENGINE TEST/MONITOR panel go off: (a) SEQUENCE TEST. (b) FUEL INJECTION TEMP OK.

Operation	Result
	(c) IGNITION COMPLETE.
	(d) MAINSTAGE OK.
	(3) MAINSTAGE OK NO. 1 PRESSURIZED and MAINSTAGE OK NO. 2 PRESSURIZED lights on ENGINE CONTROL panel go off.
y. Position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to ON.	HELIUM CONTROL light comes on; helium tank pressure vents.
z. When all pneumatic pressure has vented, return all switches and circuit breakers on test equipment to off or normal position.	All lights go off.

aa. Check all recordings to determine that engine has functioned properly. Compare oscillograph tape for last test with valve and timer operating times in figures1-11, 3-30, and 3-52, as applicable. A record of valve times must be maintained. Valve times must be determined from potentiometer traces as recorded on the oscillograph except for the ASI valve and the fuel and oxidizer bleed valves, which, since they are not on the oscillograph, must be obtained from recorder charts. See figure 3-29 for oscillograph assignments. On engines incorporating MD380 or MD381 change, redundant timer traces are superimposed on spark monitor traces. (See figure 3-52A.) Figure 3-53 may be used as an aid when reading valve traces. If valve is to be reorificed, refer to R-3825-3 for procedure.

NOTE

Errors in timing may have been caused by orifices not reinstalled in original positions, particularly orifices other than square-edged type.

aaA. Make sure the four 28-volt output signals from spark monitor panel were energized approximately 0.5 second after engine start and remained on until approximately 3.3 seconds after mainstage control valve was energized.

ab. Check event recorder tape for last test to determine that events occurred in correct sequence. See figure 3-29 for recorder assignments and figure 3-31 for sequence of events. On engines incorporating MD380 or MD381 change, redundant timer traces are superimposed on spark monitor traces. (See figure 3-52A.)

ac. The OTBV closing time in the last test must be within 50 milliseconds of closing time recorded in the preceding test.

3.2.29.3 Securing After Test.

a. Disconnect test hose from pneumatic checkout console 0-3000 PSI SUPPLY OUTLET and engine test plate 9020275.

b. Remove test plate 9020275 from HELIUM TANK FILL customer connect, and install protective covers.

bA. Remove redundant timer adapter EWR220289 from cable plug P3 and connect plug P3 to connector J-3 on SPARK MONITOR panel.

c. Install thrust chamber exit closure, or close desiccant access cover on closure.

d. Install all protective covers removed for this test.

e. Secure flight instrumentation checkout console, electrical checkout console, data recorder console, pneumatic flow tester, and pneumatic checkout console (paragraphs 3.2.30.1 through 3.2.30.5).

3.2.30 SECURING TEST EQUIPMENT.

3.2.30.1 Securing Flight Instrumentation Checkout Console G1036.

a. Return switches to off or normal positions.

b. Pull out all circuit breakers.

c. Remove cables, cap connectors and interface receptacles, and store cables in applicable console storage areas.

3.2.30.2 Securing Electrical Checkout Console G1037.

a. Return all switches to off or normal positions.

b. Pull out all circuit breakers.

c. Remove interconnect cables from engine and associated ground support equipment, cap connectors, and store cables in applicable console storage areas.

Sequence of Events	Recorded Parameters	Event	Recorder Pen Results	
			Pen Pickup	Pen Dropout
NOTE: Due to operating tolerances, the sequence of events in numbered sequence groups may vary. This is acceptable if all events occur before the first event of the next group.				
1	Engine start	On (momentarily)	3 (momentarily)	
	Helium control solenoid	Energizes	4	
	Ignition-phase control solenoid	Energizes	5	
	No. 1 ASI spark ON signal	On	23	
	No. 2 ASI spark ON signal	On	24	
	No. 1 GG spark ON signal	On	25	
	No. 2 GG spark ON signal	On	26	
	Ignition complete signal	ON	29	
	Start tank discharge delay timer	Starts	(a)	(a)
	Oxidizer bleed valve	Closes	34	
	Fuel bleed valve	Closes	35	
	MOV	Opens	7	6
	ASI valve	Opens	8	
2	Start tank discharge delay timer	Expires	(a)	(a)
	STDV control solenoid	Energizes	9	
	Ignition-phase timer	Starts	(a)	(a)
	STDV	Opens	11	10
3	Ignition-phase timer	Expires	(a)	(a)
	Mainstage control solenoid	Energizes	12	
	Sparks deenergize timer	Starts	(a)	(a)
	STDV control solenoid	Deenergizes		9

(a) Recorded on oscillograph only.

Figure 3-31. Engine Sequence Test--Sequence of Events (Sheet 1 of 2)

Sequence of Events	Recorded Parameters	Event	Recorder Pen Results	
			Pen Pickup	Pen Dropout
3 (cont)	STDV	Closes	10	11
	MOV	Opens	15	13
	GG valve	Opens	17	16
	OTBV	Closes	18	19
4	Sparks deenergize timer	Expires	(a)	(a)
	No. 1 ASI spark ON signal	Off		23
	No. 2 ASI spark ON signal	Off		24
	No. 1 GG spark ON signal	Off		25
	No. 2 GG spark ON signal	Off		26
	Ignition complete signal	Off		29
5	Cutoff	On	39	
	Cutoff lockin	On	40	
	Helium control deenergize timer	Starts	(a)	(a)
	Mainstage control solenoid	Deenergizes		12
	Ignition-phase control solenoid	Deenergizes		5
	MFV	Closes	6	7
	GG valve	Closes	16	17
	MOV	Closes	13	15
	ASI valve	Closes		8
	OTBV	Opens	19	18
6	Helium control deenergize timer	Expires	(a)	(a)
	Helium control solenoid	Deenergizes		4
	Oxidizer bleed valve	Opens		34
	Fuel bleed valve	Opens		35

(a) Recorded on oscillograph only.

Figure 3-31. Engine Sequence Test--Sequence of Events (Sheet 2 of 2)

3.2.30.3 Securing Data Recorder Console G3121.

a. Return switches to off or normal positions.

b. Pull out all circuit breakers.

c. Remove interconnect cables, cap connectors and interface receptacles, and store cables in applicable console storage areas.

3.2.30.4 Securing Pneumatic Checkout Console G3106.

a. Adjust facility pneumatic supply of pneumatic checkout console to zero.

NOTE

Steps b and c vent all pressure from pneumatic checkout console.

b. Open BLEED and REG SUPPLY SHUTOFF valves on PNEUMATIC SUPPLY PANEL (0-3000).

c. Turn PRESSURE REGULATOR on PNEUMATIC SUPPLY PANEL (0-3000) to INCREASE. Allow all pressure to bleed from pneumatic checkout console.

d. Open all bleed valves, and close all shutoff valves.

e. Turn all pressure regulators fully counterclockwise.

f. When all pneumatic pressure is vented from console, remove hose from console to facility supply.

g. Remove test hoses, cap hose ends with clean closures, and store hoses in applicable storage areas of pneumatic checkout console.

h. Return switch to off position, remove cable from console interface to electrical console, cap connectors, and store cable in electrical console.

i. Install protective caps on interface fittings.

3.2.30.5 Securing Pneumatic Flow Tester G3104. Secure, inspect, and clean loose equipment as outlined in R-3825-5.

3.2.31 SECURING ENGINE. Secure engine after testing as follows:

a. Remove test plates, place in proper kit containers, and store in pneumatic checkout console.

b. Using a clean, dry cloth, remove all leak compound from engine.

c. Install covers and closures.

d. Replace desiccants in turbopump inlet ducts and thrust chamber exit closures if humidity indicators indicate over 30 percent. (Refer to section II for desiccant installation requirements.)

e. Install protective covers on electrical receptacles.

f. Safetywire bolts, as required, on flanges disconnected for engine testing.

g. If engine is to be transported, install security cover as outlined in R-3825-3.

3.3 STAGE-INSTALLED-ENGINE TEST PROCEDURES.

3.3.1 Each test in the following paragraphs is complete as an individual procedure; however tests may be performed in a series if desired. In such cases, securing procedures indicated at the end of each test may be postponed until the series of tests is complete. Naflex seals removed and installed during checkout procedures must be handled as outlined in R-3825-3.

3.3.2 ENGINE LEAK-TEST POINTS. Figure 3-32 outlines the leak-test point location and the type of leak test to be accomplished at each point. Figure 3-33 is an instrumentation tap location schematic that can be used as an aid when leak-testing instrumentation systems.

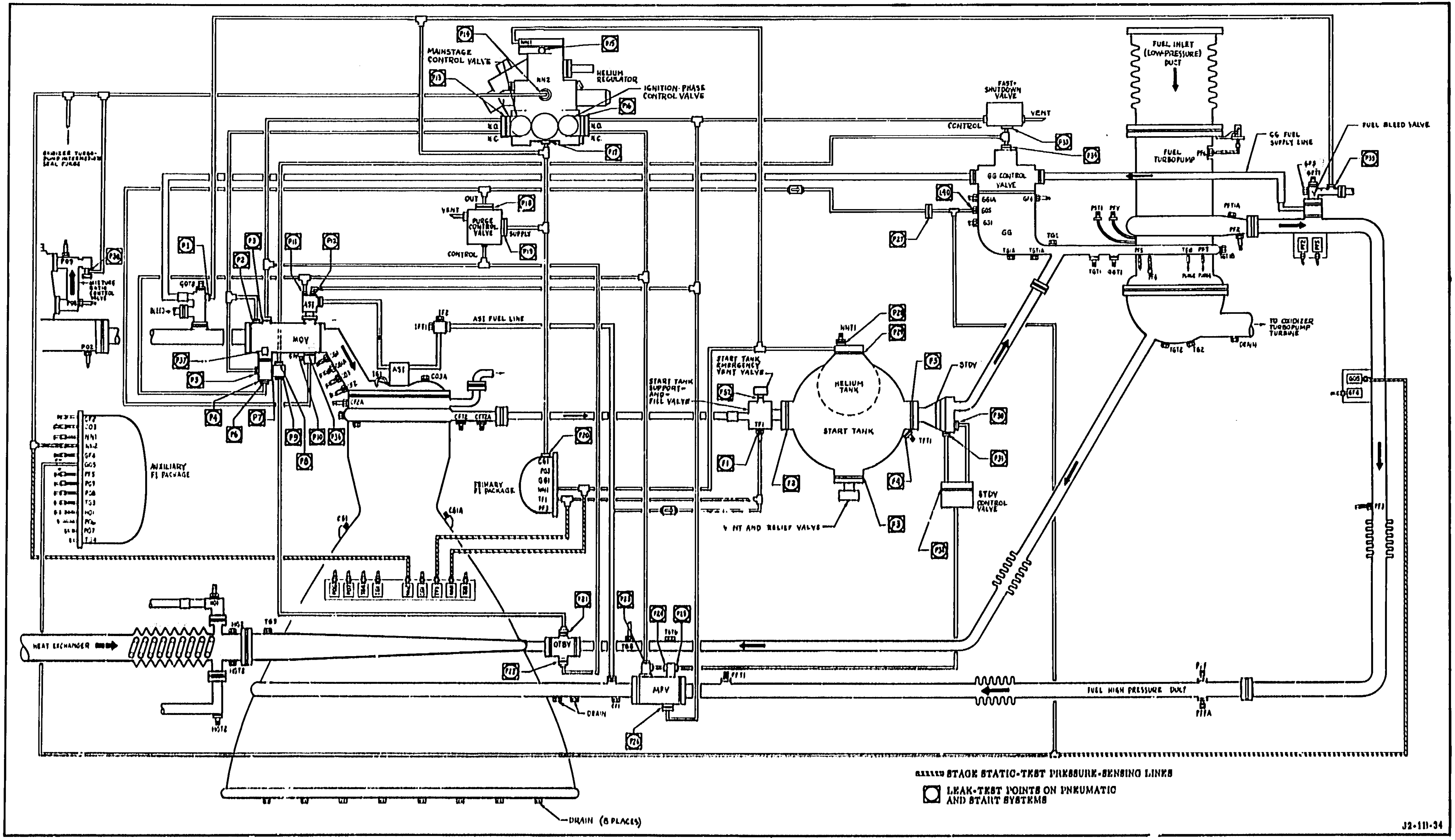


Figure 3-32. Engine Leak-Test Points (Sheet 1 of 14)

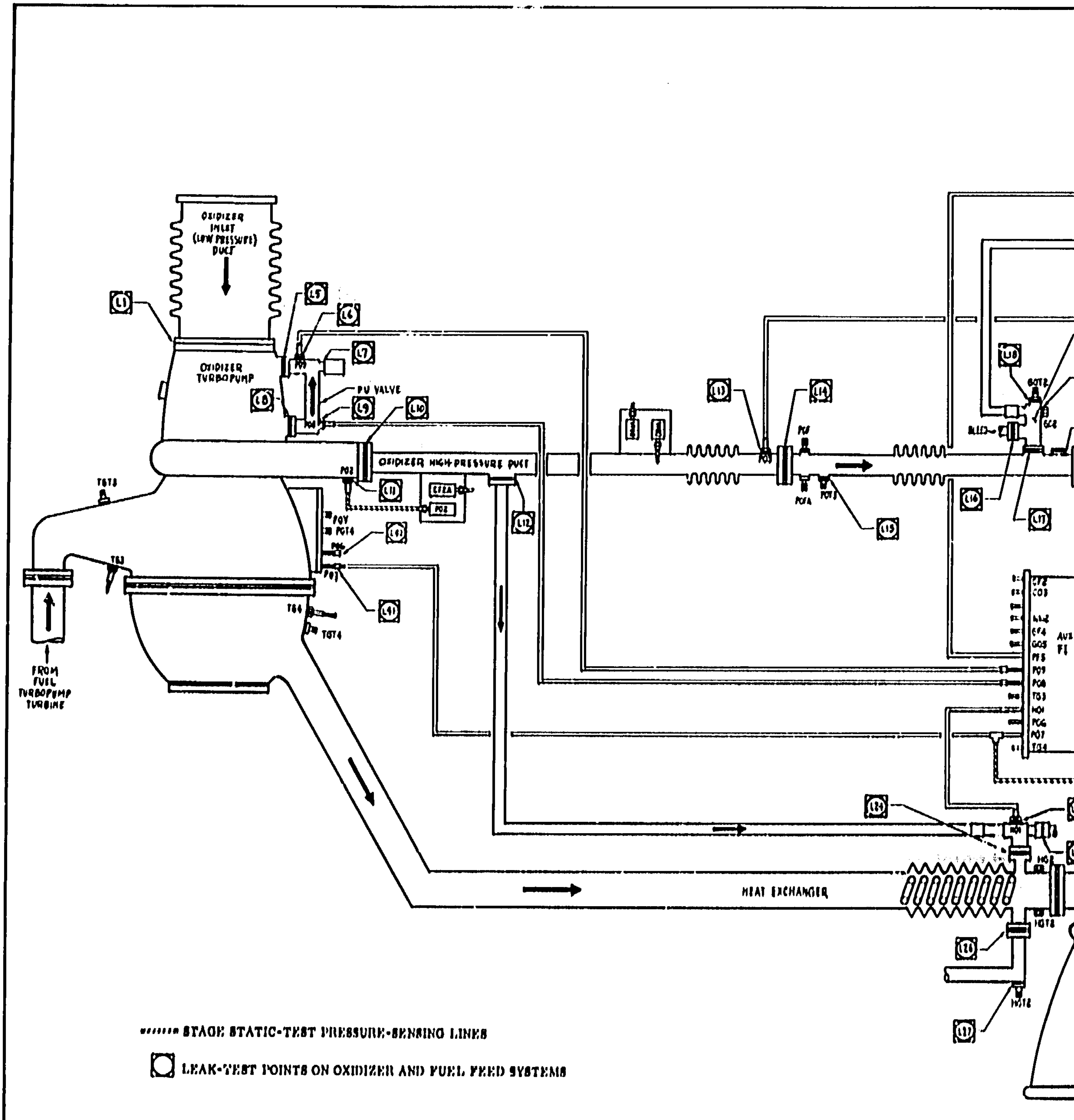
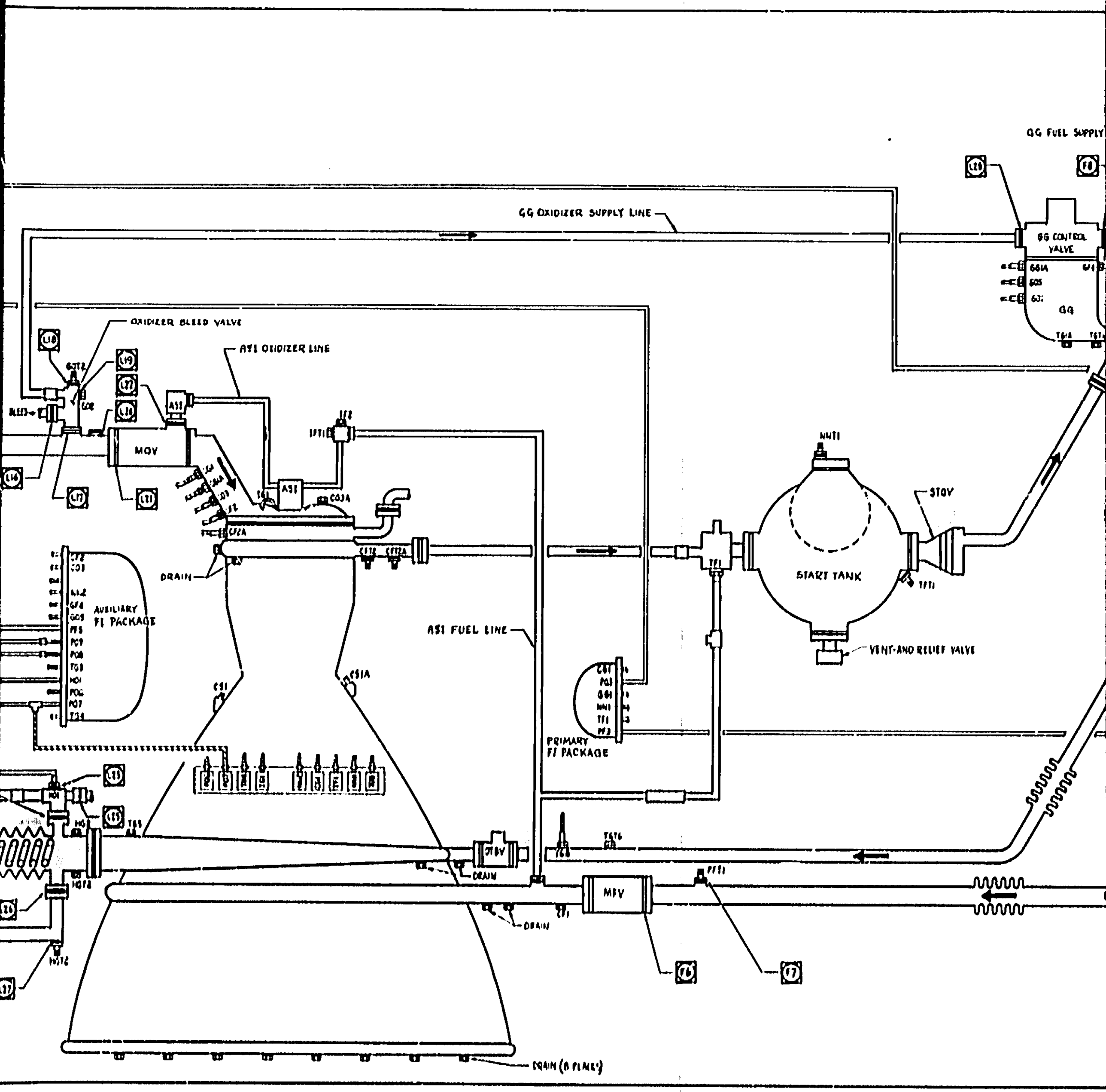
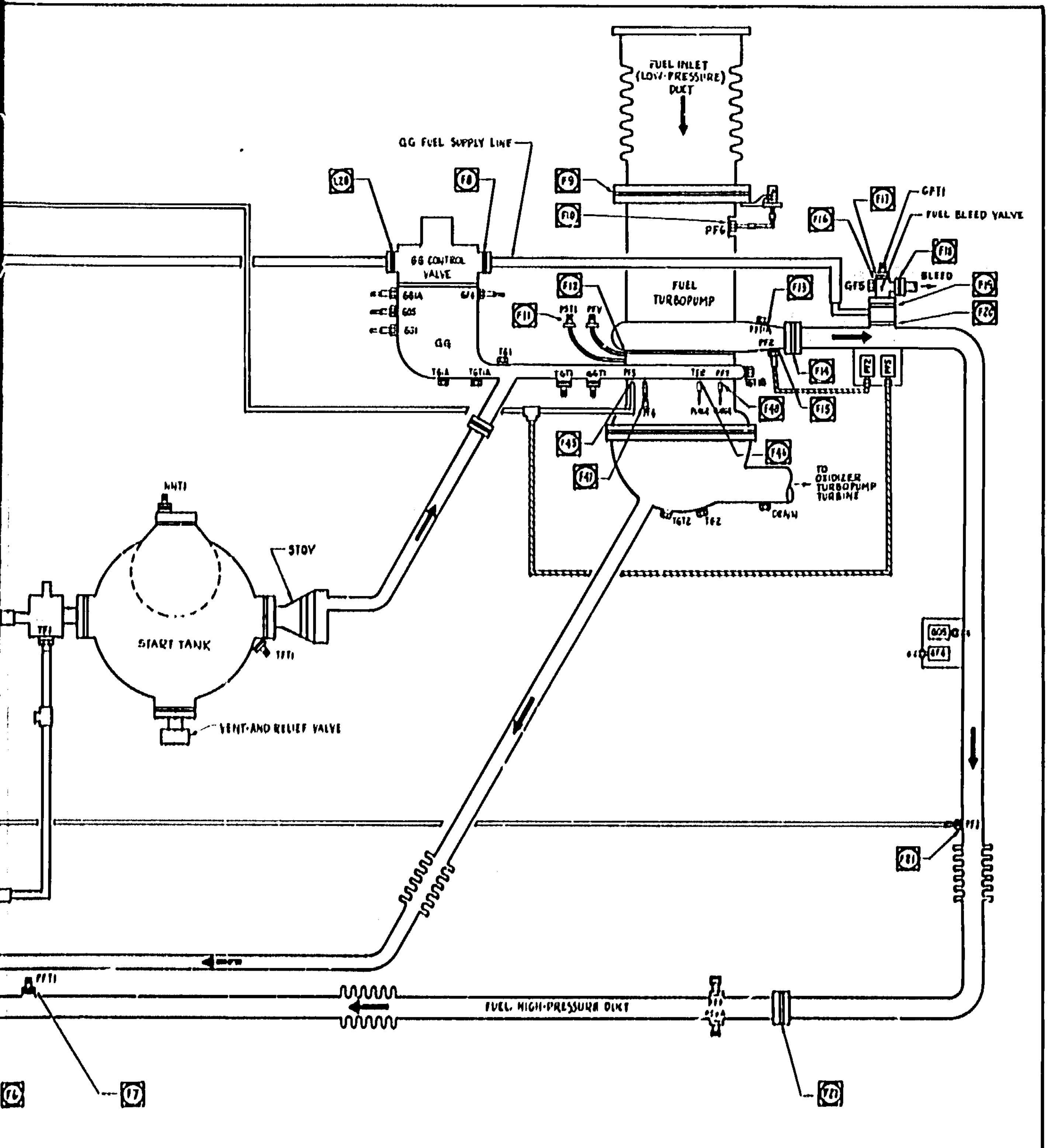


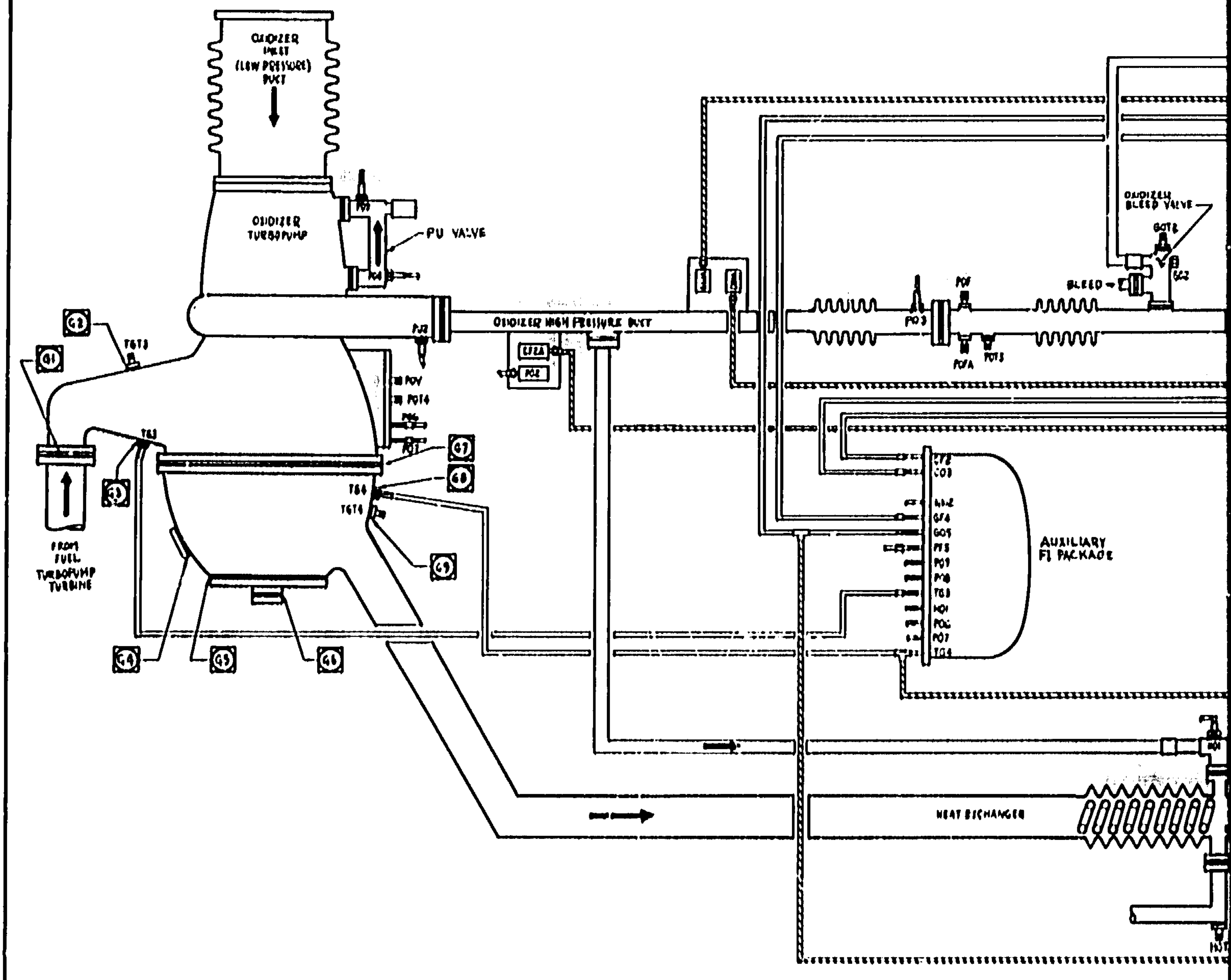
Figure 3-32. Engine Leak-Test Points (Sheet 2 of 14)



GG FUEL SUPPLY
GG OXIDIZER SUPPLY LINE
GG CONTROL VALVE
GG
OXIDIZER BLEED VALVE
ASI OXIDIZER LINE
BLEED
MOV
ASI
START TANK
STDV
VENT-AND RELIEF VALVE
DRAIN
AUXILIARY FI PACKAGE
ASI FUEL LINE
PRIMARY FI PACKAGE
MFV
DRAIN (8 PLACES)


FUEL INLET (LOW-PRESSURE) DUCT
GG FUEL SUPPLY LINE
GG CONTROL VALVE
GG
FUEL TURBOPUMP
FUEL BLEED VALVE
BLEED
START TANK
STDV
VENT AND RELIEF VALVE
TO OXIDIZER TURBOPUMP TURBINE
FUEL HIGH-PRESSURE DUCT

J2-11-11D



•••••••• STAGE STATIC-TEST PRESSURE-SENSING LINES

LEAK-TEST POINTS ON GG EXHAUST SYSTEM AND THRUST CHAMBER

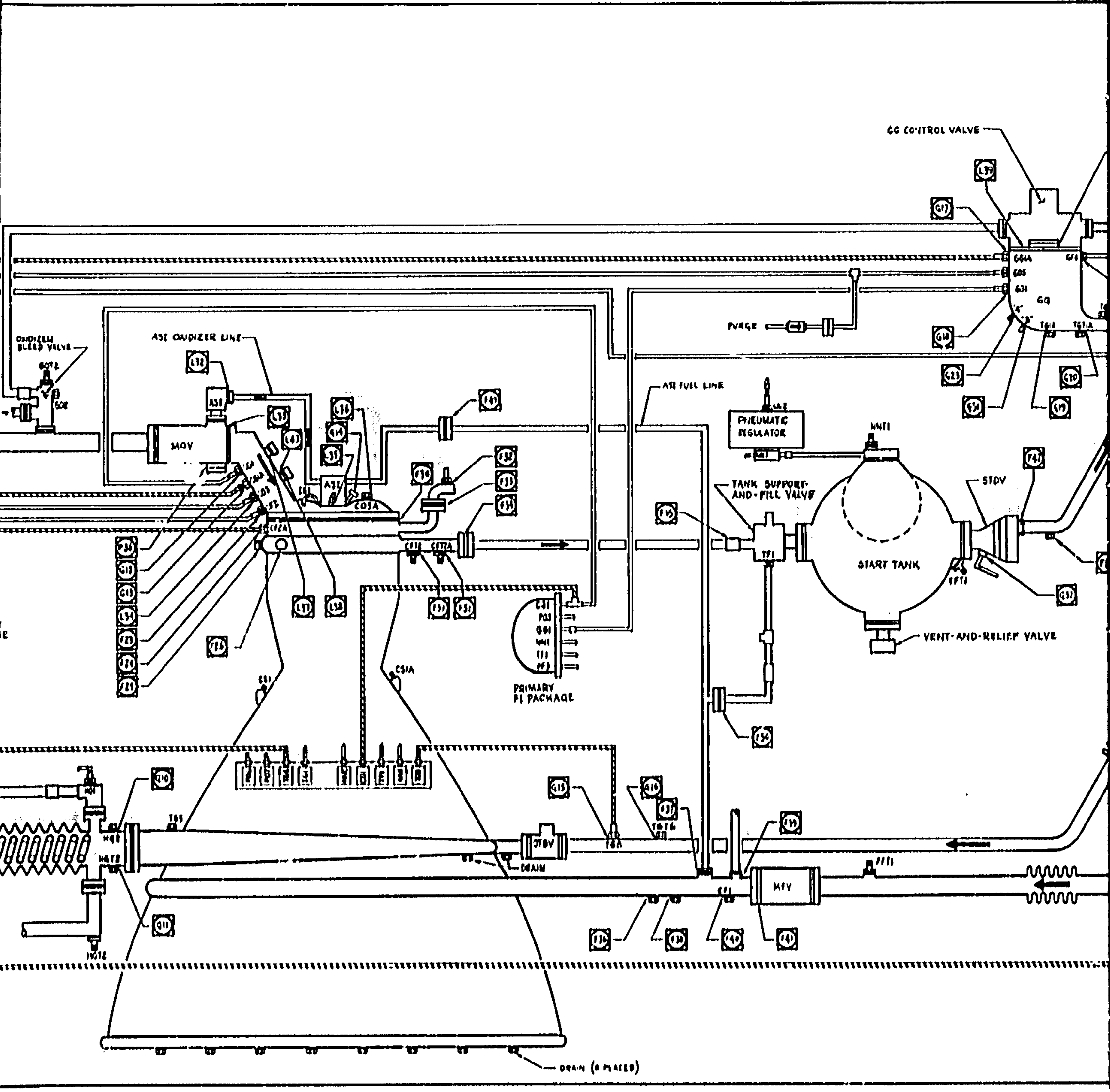

GG CONTROL VALVE
GG
PURGE
OXIDIZER BLEED VALVE
ASI OXIDIZER LINE
MOV
ASI FUEL LINE
PNEUMATIC REGULATOR
TANK SUPPORT-AND-FILL VALVE
START TANK
STDV
VENT-AND-RELIEF VALVE
PRIMARY FI PACKAGE
DRAIN
MFV
DRAIN (8 PLACES)

Figure 3-32.

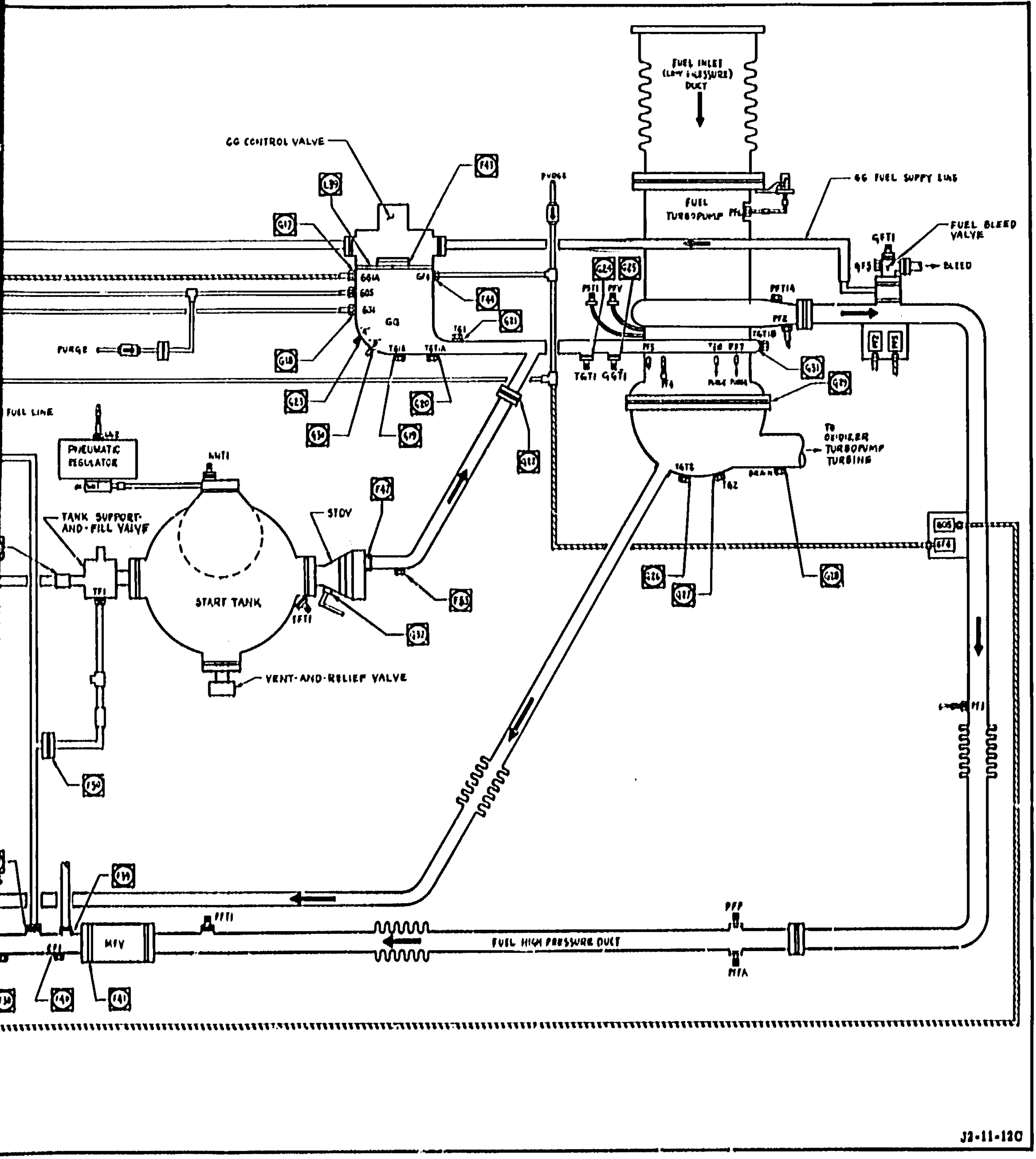


Figure 3-32. Engine Leak-Test Points (Sheet 3 of 14)

Leak-Test Point Description	Code	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
Helium regulator assembly regulated pressure outlet port NN2	P14	X	
NN2 line to auxiliary FI package			X
NN2 line from tee to static-test transducer[a]			X
Helium regulator assembly high-pressure inlet line NN1	P15	X	
NN1 line to primary FI package			X
NN1 line from tee to static-test transducer[a]			X
NN1 line from tee to auxiliary FI package[b]			X
Ignition-phase control valve connection to ignition-phase control valve manifold	P16	X	
Helium regulator assembly check valve and line outlet flange	P17	X	
Purge control valve outlet line flange	P18	X	
Purge control valve inlet line flange	P19	X	
Pneumatic accumulator inlet line flange (primary FI package) (2 places)	P20	X	
OTBV closing control port	P21	X	
OTBV opening control port	P22	X	
MFV opening control port	P23	X	
MFV sequence valve inlet port	P24	X	
MFV sequence valve outlet port	P25	X	
MFV closing control port	P26	X	
GG oxidizer purge line flange	P27	X	
Helium tank temperature transducer (NNT1)	P28	X	
Helium tank connection to helium cover and fill-check valve	P29	X	

(a) Engines not incorporating MD160, MD280, or MD281 change.
(b) Engines incorporating MD269, MD282, MD290, MD313, or MD316 change.

Figure 3-32. Engine Leak-Test Points (Sheet 5 of 14)

Leak-Test Point Description	Code	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
STDV opening control port	P30	X	
STDV closing control port	P31	X	
STDV control valve connection to adapter	P32	X	
Fast-shutdown valve inlet port	P33	X	
GG opening control port	P34	X	
Fuel bleed valve closing control port	P35	X	
MRCV pneumatic inlet port[w]	P38	X	
Start tank pressure port TF1	F1	X	
TF1 line to primary FI package			X
TF1 line to auxiliary FI package[b]			X
TF1 line from tee to static-test transducer[a]			X
Start tank liquid refill line from ASI fuel line to check valve and to start tank support-and-fill valve			X
Start tank support-and-fill valve connection to start tank	F2	X	
Start tank joints and seams			X
Start tank vent-and-relief valve connection to start tank	F3	X	
Start tank temperature transducer TFT1	F4	X	
STDV connection to start tank	F5	X	
Start tank emergency vent valve connection to start tank support-and-fill valve[c]	F52	X	
Blank plate on start tank support-and-fill valve[d]	F52	X	
Oxidizer inlet duct connection to turbopump	L1	X	
PU valve outlet flange connection to turbopump[v]	L5	X	
MRCV outlet flange connection to turbopump[w]	L5	X	

(a) Engines not incorporating MD150, MD280, or MD281 change.
(b) Engines incorporating MD269, MD282, MD290, MD313, or MD315 change.
(c) Engines incorporating MD320 change.
(d) Engines not incorporating MD320 change.
(v) Engines not incorporating MD366 or MD371 change.
(w) Engines incorporating MD366 or MD371 change.

Figure 3-32. Engine Leak-Test Points (Sheet 6 of 14)

Leak-Test Point Description	Code	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
PU valve outlet pressure instrumentation port PO9[v]	L6	X	
PO9 line to auxiliary FI package			X
PU valve connection to PU valve actuator[v]	L7	X	
MRCV pneumatic actuator housing to valve gate housing[w]	L7	X	
PU valve inlet flange connection to turbopump outlet manifold[v]	L8	X	
PU valve inlet pressure instrumentation port PO8[v]	L9	X	
PO8 line to auxiliary FI package			X
MRCV outlet pressure instrumentation port PO9[w]	L6	X	
PO9 line to auxiliary FI package			X
MRCV inlet flange connection to turbopump outlet manifold[w]	L8	X	
MRCV inlet pressure instrumentation port PO8[w]	L9	X	
PO8 line to auxiliary FI package			X
Oxidizer turbopump connection to oxidizer high-pressure duct	L10	X	
Oxidizer turbopump discharge pressure instrumentation port PO2[e]	L11		X
PO2 line to static-test transducer[a][e]			X
Heat exchanger oxidizer supply line connection to oxidizer high-pressure duct	L12	X	
Oxidizer turbopump discharge pressure instrumentation port PO3	L13	X	
PO3 line to primary FI package			X
PO3 line from tee to static-test transducer[f]			
Oxidizer flowmeter flange	L14	X	
Oxidizer turbopump discharge fluid temperature transducer POT3	L15	X	
Oxidizer bleed line connection to oxidizer bleed valve	L16	X	
Oxidizer bleed valve connection to oxidizer high-pressure duct	L17	X	
Oxidizer bleed valve - oxidizer temperature port GOT2	L18	X	

(a) Engines not incorporating MD150, MD280, or MD281 change.
(e) Engines not incorporating MD237 change.
(f) Engines incorporating MD237 change but not incorporating MD150, MD280, or MD281 change.
(v) Engines not incorporating MD366 or MD371 change.
(w) Engines incorporating MD366 or MD371 change.

Figure 3-32. Engine Leak-Test Points (Sheet 7 of 14)

Leak-Test Point Description	Code	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
Oxidizer bleed valve capped port GO2[e]	L19	X	
Blank plate on oxidizer high-pressure duct	L20	X	
MOV upstream flange	L21	X	
ASI valve flange connection to MOV	L22	X	
Heat exchanger oxidizer inlet pressure instrumentation port HO1[g]	L23	X	
HO1 line to auxiliary FI package[g]			X
Heat exchanger antiflood check valve connection to heat exchanger[g]	L24	X	
Helium inlet line connection to heat exchanger[h]	L24	X	
Bypass line flange connection to antiflood check valve[g], or to blank plate[h]	L25	X	
Heat exchanger outlet flange	L26	X	
Heat exchanger outlet temperature transducer HOT2[g], or plate over transducer mounting port[h]	L27	X	
GG oxidizer line connection to GG	L28	X	
Oxidizer turbopump bearing coolant pressure instrumentation line PO7 at weld bracket	L41		X
PO7 line to auxiliary FI package[i]			X
PO7 line from tee to static-test transducer[i]			X
PO7 line plug[b]			X
Oxidizer turbopump primary seal cavity pressure instrumentation line PO6 at weld bracket	L42		X
PO6 line to auxiliary FI package			X
PO6 line from tee to static-test transducer[a]			

(a) Engines not incorporating MD150, MD280, or MD281 change.
(b) Engines incorporating MD269, MD282, MD296, MD313, or MD315 change.
(e) Engines not incorporating MD237 change.
(g) Engines not incorporating MD105 or MD194 change.
(h) Engines incorporating MD105 or MD194 change.
(i) Engines not incorporating MD269, MD282, MD296, MD313, or MD315 change.

Figure 3-32. Engine Leak-Test Points (Sheet 8 of 14)

Leak-Test Point Description	Code	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
MFV upstream flange	F6	X	
Fuel turbopump discharge fluid-temperature transducer PFT1	F7	X	
GG fuel line connection to GG	F8	X	
Fuel inlet duct to turbopump	F9	X	
Fuel turbopump interstage pressure instrumentation port PF6	F10	X	
PF6 line to transducer(k)			X
Fuel turbopump bearing temperature transducer PST1(j)	F11		X
Fuel turbopump to support (below pump volute)	F12	X	
Fuel turbopump discharge fluid-temperature transducer PFT1a	F13	X	
Fuel turbopump to fuel high-pressure duct	F14	X	
Fuel turbopump discharge pressure instrumentation port PF2(l)	F15	X	
Fuel turbopump discharge pressure instrumentation port PF2(a)	F15		X
PF2 line to static-test transducer(a)			X
Fuel bleed valve capped port GF5(e)	F16	X	
Fuel bleed valve fuel temperature transducer GFT1	F17	X	
Fuel bleed line connection to fuel bleed valve	F18	X	
Fuel bleed valve connection to fuel bleed valve adapter	F19	X	
Fuel high-pressure duct connection to fuel bleed valve adapter	F20	X	
Fuel turbopump discharge pressure instrumentation port PF3	F21	X	
PF3 line to primary FI package			X

(a) Engines not incorporating MD150, MD280, or MD281 change.
(e) Engines not incorporating MD237 change.
(j) Engines not incorporating MD172 change.
(k) Engines not incorporating MD233 change.
(l) Engines incorporating MD150, MD280, or MD281 change.

Figure 3-32. Engine Leak-Test Points (Sheet 9 of 14)

Leak-Test Point Description	Code	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
Fuel flowmeter flange	F22	X	
Fuel turbopump balance piston cavity pressure instrumentation port PF5	F45		X
PF5 line to auxiliary FI package			X
PF5 line from tee to static-test transducer[a]			X
Fuel turbine seal purge line (TG10) at weld bracket	F46		X
Fuel turbopump balance piston sump pressure at capped line (PF4)	F47		X
Fuel turbopump primary seal purge line (PR7) at weld bracket	F48		X
Fuel turbine exhaust duct connection to oxidizer turbine inlet	G1	X	
Oxidizer turbine inlet temperature transducer TGT3[m]	G2	X	
Oxidizer turbine inlet pressure instrumentation port TG3	G3	X[e]	X[n]
TG3 line to auxiliary FI package			X
Oxidizer turbopump torque-access plate	G4	X	
Oxidizer turbopump accessory drive pad connection to turbine exhaust duct	G5	X	
Oxidizer turbopump accessory drive pad access plug	G6	X	
Oxidizer turbopump connection to turbine exhaust duct	G7	X	
Oxidizer turbine exhaust pressure instrumentation port TG4	G8	X[e]	X[n]
TG4 line to auxiliary FI package			X
TG4 line from tee to static-test transducer[a]			

(a) Engines not incorporating MD160, MD280, or MD281 change.
(e) Engines not incorporating MD237 change.
(m) On engines incorporating MD263 change but not incorporating MD274 change, the temperature transducer port is plugged.
(n) Engines incorporating MD237 change.

Figure 3-32. Engine Leak-Test Points (Sheet 10 of 14)

Leak-Test Point Description	Code	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
Oxidizer turbine exhaust temperature transducer TGT4(m)	G9	X	
Heat exchanger pressure instrumentation port HG2(e)	G10	X	
Heat exchanger temperature instrumentation port HGT2(e)	G11	X	
OTBV nozzle inlet pressure instrumentation port TG8(e)	G15	X	
TG8 line to static-test transducer(a)(o)			X
OTBV nozzle inlet temperature transducer TGT6(e)	G16	X	
GG chamber pressure instrumentation port GG1a(e)	G17		X
GG1a line to static-test transducer(a)(e)			X
GG chamber pressure instrumentation port GG1(e)	G18	X	
GG1 line to primary FI package(e)			X
Fuel turbine inlet pressure instrumentation port TG1a(p)	G19	X	
Fuel turbine inlet temperature transducer TGT1a(e)	G20	X	
Fuel turbine inlet pressure instrumentation port TG1(e)(p)	G21	X	
Fuel turbine inlet manifold connection to STDV hose	G22	X	
GG spark igniter "A" port	G23	X	
Fuel turbine inlet temperature transducer TGT1(m)	G24	X	

(a) Engines not incorporating MD150, MD280, or MD281 change.
(e) Engines not incorporating MD237 change.
(m) On engines incorporating MD263 change but not incorporating MD274 change, the temperature transducer port is plugged.
(o) Engines not incorporating MD226 change.
(p) Engines not incorporating MD136 change.

Figure 3-32. Engine Leak-Test Points (Sheet 11 of 14)

Leak-Test Point Description	Code	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
GG overtemperature transducer GGT1	G25	X	
Fuel turbine exhaust temperature transducer port TGT2	G26	X	
Fuel turbine exhaust pressure transducer port TG2	G27	X	
Fuel turbine exhaust duct drain port	G28	X	
Fuel turbopump connection to turbine exhaust duct	G29	X	
STDV drain line connection to STDV	G32	X	
Instrumentation port on STDV discharge hose	F53	X	
Start-tank discharge hose connection to STDV	F42	X	
GG fuel valve connection to injector	F43	X	
GG fuel injector pressure and purge line pressure instrumentation port GF4	F44	X	
GF4 line to auxiliary FI package			X
GF4 line from tee to static-test transducer(a)			X
GG oxidizer valve connection to injector	L39	X	
GG oxidizer injector pressure and purge line pressure instrumentation port GO5	L40	X	
GO5 line to auxiliary FI package			X
GO5 line from tee to static-test transducer(a)			X
GG spark igniter "B" port	G30	X	
Fuel turbine inlet temperature transducer port TGT1b(e)	G31	X	
Fuel turbine inlet pressure instrumentation port TG1(q)	G31	X	
TG1 line to primary FI package(n)			X
ASI valve connection to ASI oxidizer line	L32	X	

(a) Engines not incorporating MD150, MD280, or MD281 change.
(e) Engines not incorporating MD237 change.
(n) Engines incorporating MD237 change.
(q) On engines incorporating MD237 change, "TGT1b" is changed to "TG1", and an instrumentation line is routed to the primary FI package.

Figure 3-32. Engine Leak-Test Points (Sheet 12 of 14)

Leak-Test Point Description	Code	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
MOV downstream flange	L33	X	
Main oxidizer injection pressure port CO3	L34	X	
CO3 line to auxiliary FI package			X
Flange seal between ASI and thrust chamber injector	L35	X	
Main oxidizer injection pressure port CO3a	L36	X	
Mainstage OK pressure switch No. 1	L37	X	
Mainstage OK pressure switch No. 2 to adapter	L38	X	
Mainstage OK pressure switch No. 2 adapter connection to oxidizer injector	L43	X	
Thrust chamber pressure port CG1	G12	X	
CG1 line to primary FI package			X
CG1 line from tee to static-test transducer[a]			X
Thrust chamber pressure port CG1a	G13		X
CG1 line to static-test transducer[a]			X
Ignition detector probe flange	G14	X	
Main fuel injection pressure port CF2	F23	X	
CF2 line to auxiliary FI package			X
CF2 line to static-test transducer "CF2a"[f]			X
Main fuel injection pressure port CF2a	F24		X
CF2a line to static-test transducer "CF2a"[a][e]			X
Drain port on thrust chamber forward fuel manifold	F25	X	
Drain port on thrust chamber forward fuel manifold	F26	X	

(a) Engines not incorporating MD150, MD280, or MD281 change.
(e) Engines not incorporating MD237 change.
(f) Engines incorporating MD237 change but not incorporating MD150 change.

Figure 3-32. Engine Leak-Test Points (Sheet 13 of 14)

Leak-Test Point Description	Code	Leak-Test Point Using Pneumatic Flowtester	Leak-Test Point Using Leak-Test Compound
Thrust chamber injector connection to thrust chamber forward fuel manifold	F30	X	
Main fuel injection temperature transducer CFT2	F31	X	
Hydrogen tapoff (tank pressurization) line pressure port HF2[(r)(s)]	F32	X	
Hydrogen tank pressurization line connection to forward fuel manifold	F33	X	
Hydrogen tank pressurization flange plate[(t)]	F33	X	
Start tank gaseous (hydrogen) refill line forward fuel manifold	F34	X	
Start tank gaseous (hydrogen) refill line to start tank support-and-fill valve	F35		X
Thrust chamber fuel inlet manifold drain port	F36	X	
ASI fuel line connection to thrust chamber fuel inlet manifold	F37	X	
Thrust chamber fuel inlet manifold drain port	F38	X	
Thrust chamber jacket purge line and fuel jacket purge check valve connection to fuel inlet manifold	F39	X	
Thrust chamber jacket purge line to check valve (upstream side)			X
Thrust chamber jacket purge manifold pressure port CF1	F40	X	
MFV downstream flange	F41	X	
Upper and lower ASI fuel line flange connection	F49	X	
ASI fuel line start tank liquid refill flange	F50	X	
Main fuel injection temperature transducer CFT2a[(u)]	F51	X	
Oxidizer injector purge check valve connection to MOV	P36		X

(r) Engines not incorporating MD156 change or on engines incorporating MD182 change.
(s) Engines not incorporating MD206 change.
(t) Engines incorporating MD156 change but not incorporating MD182 change.
(u) Engines not incorporating MD262 change.

Figure 3-32. Engine Leak-Test Points (Sheet 14 of 14)

1 Removed on engines incorporating MD105 or MD194 change.

2 Removed on engines incorporating MD237 change.

3 Two lines teed together on engines incorporating MD237 change.

4 Removed on engines incorporating MD172 or MD206 change.

5 Removed on engines incorporating MD269, MD282, MD296, MD313, or MD315 change.

6 Removed on engines incorporating MD192 or MD246 change.

7 Redundant instrumentation added on engines incorporating MD269, MD282, MD296, MD313, or MD315 change.

8 Removed on engines incorporating MD304 change.

9 Removed on engines incorporating MD233 change.

10 Engines incorporating MD237 change.

11 Removed on engines incorporating MD136 change.

12 Removed on engines incorporating MD262 change.

13 Engines incorporating MD200 change.

14 Removed on engines incorporating MD100 change.

15 Removed on engines incorporating MD172 change.

16 Engines incorporating MD327, MD328, MD329, MD332, or MD334 change.

17 Engines incorporating MD331 or MD344 change but not incorporating MD347 change.

18 Engines not incorporating MD263 or MD355 change.

19 Engines incorporating MD347 change.

Figure 3-33. Instrumentation Tap Location Schematic (Sheet 2 of 2)

3.3.3 INSTALLING EXHAUST SYSTEM TEST PLATES ON STAGE-INSTALLED ENGINE.

CAUTION

Adapter 9022823 must be installed in the torque access of the fuel turbine exhaust duct any time the exhaust system test plates are installed. Failure to install adapter 9022823 can result in overpressurization of the exhaust system.

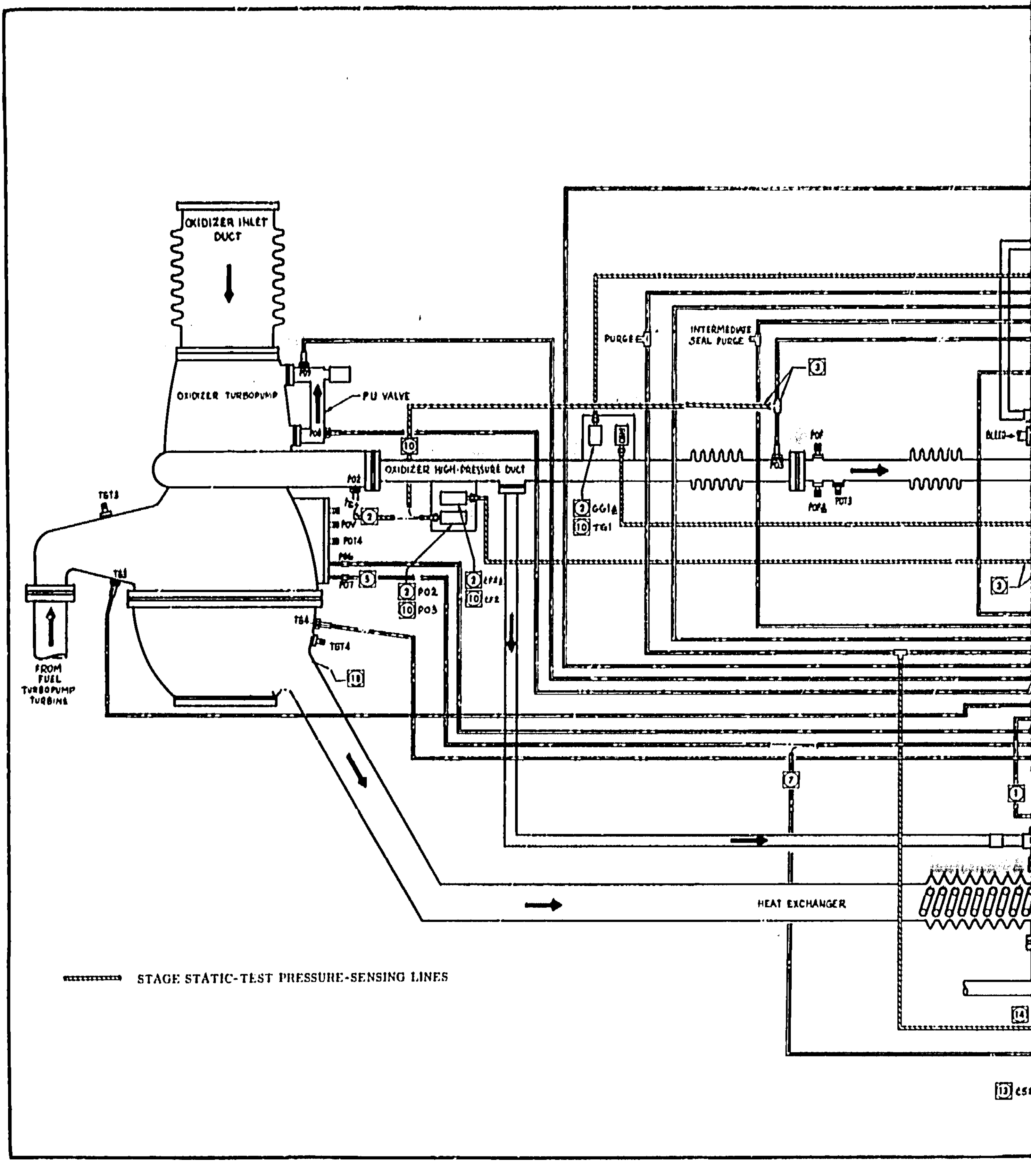
a. Remove plug and seal from torque access of fuel turbine exhaust duct and install adapter 9022823 in torque access. Torque adapter to 50-60 in-lb.

b. Disconnect closing control pressure line and remove seal from OTBV.

c. Install test plate 9020251-11 from test plate kit 9016723-11 on closing control port. Torque bolts to 41-45 in-lb. Make sure bleed valve on test plate is closed.

cA. Install test plate EWR225307 from test plate kit EWR225308 on closing control line when engine pneumatic system is going to be pressurized. If engine pneumatic system is not going to be pressurized, install protective closure on line.

d. Disconnect opening control pressure line and remove seal from OTBV. Remove orifice and retain for reinstallation. Install test plate 9025399 from test plate kit 9025400-11 between line and opening control port. Torque bolts to 41-45 in-lb.



STAGE STATIC-TEST PRESSURE-SENSING LINES

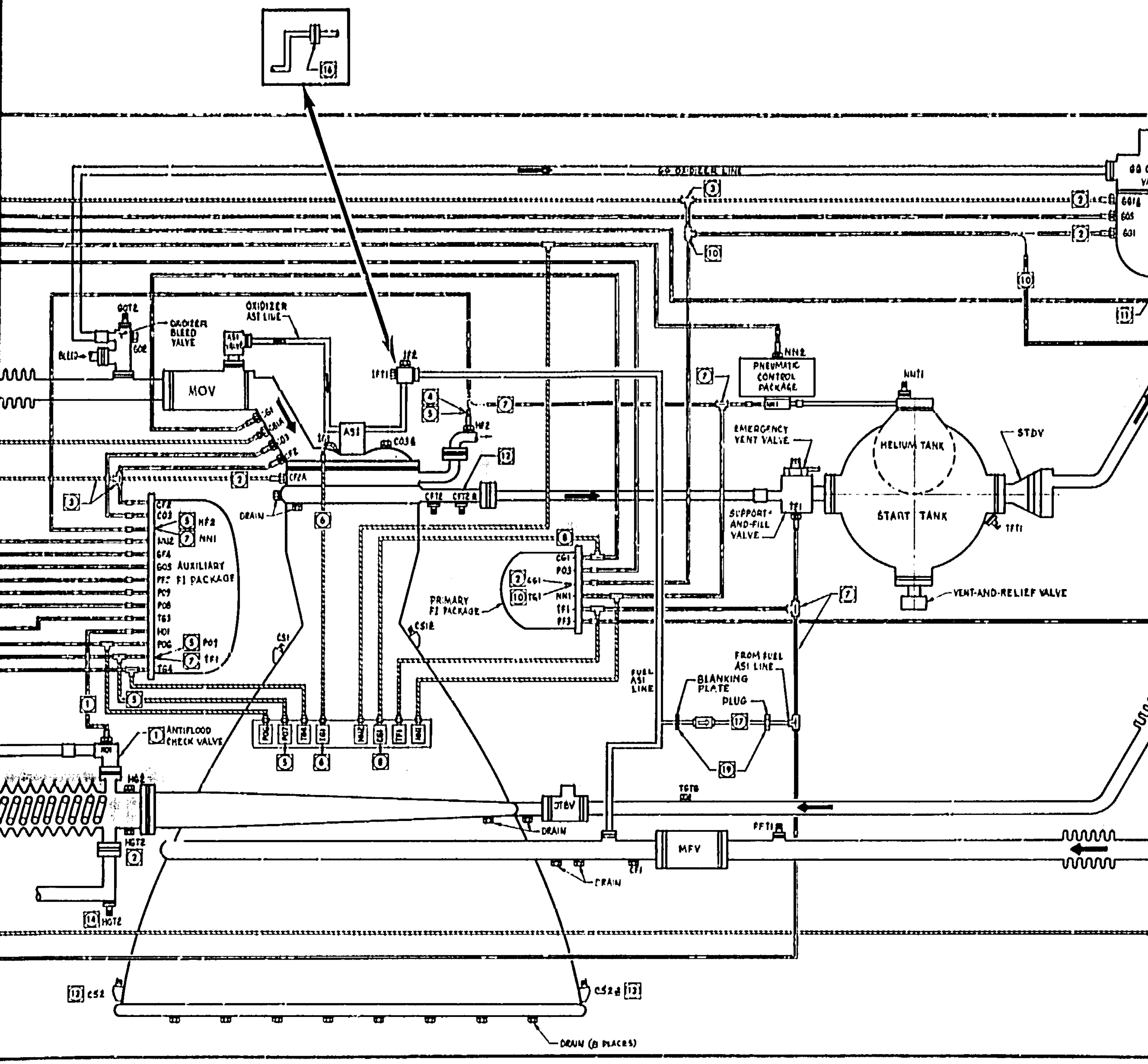


Figure 3-33. Instru

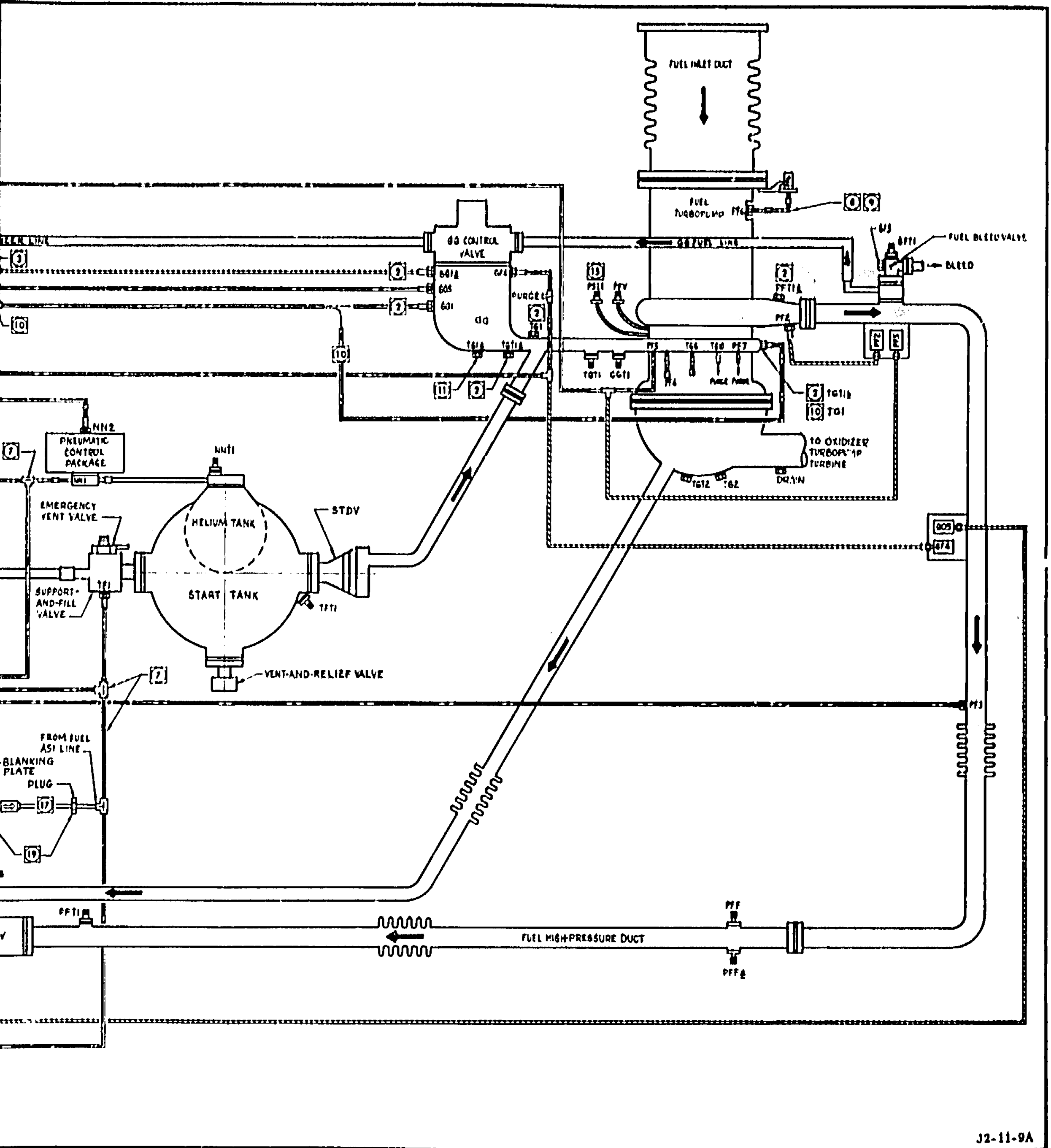


Figure 3-33. Instrumentation Tap Location Schematic (Sheet 1 of 2)

Operation	Result
e. Connect a regulated pneumatic source capable of supplying 0-1,000 psig to test plate 9020251-11.	
f. Slowly increase pressure to test plate 9020251-11 to 400 ±25 psig.	OTBV closes.

g. Remove flange-attaching bolts in vicinity of 1/4-inch holes in upper and lower duct flanges to allow installation of OTBV removal tool 9020269.

CAUTION

Extension of bracket must be minimal to prevent distortion when attaching bolts are installed.

h. Position bracket 9021015 at lower duct flange with extended portion upstream (towards fuel turbine exhaust duct).

i. Position bracket 9021016 at upper duct flange and install opening in bracket over extension of bracket 9021015. Secure both brackets using bolt AN103811 and washers LD153-0011-0014.

j. Remove flange attaching bolts, leaving enough bolts without nuts to prevent valve and upstream seal from dropping when duct bellows is compressed.

k. Rotate hex extension of lower bracket until enough clearance is obtained between thrust chamber exhaust manifold and valve flange to allow removal of downstream seal.

l. Withdraw remaining attaching bolts only enough to remove seal; then remove seal.

m. Install test plate 9020225 from test plate kit 9016701-11 on downstream side of OTBV with attaching bolts. Rotate hex extension to allow bellows to extend until manifold flange is alined with valve.

NOTE

Tool brackets may be left installed for reinstallation of tool.

n. Reinstall attaching bolts, washers, and nuts using a minimum of every other bolthole in flange. Torque nuts to 75-84 in-lb.

o. Decrease closing control pressure to zero.

p. Install oxidizer heat-exchanger handler 9016700-11 on bellows of heat exchanger. Do not compress bellows during installation.

q. Remove bolts from downstream flange, leaving enough bolts without nuts to prevent seal and orifice from dropping when bellows is compressed.

NOTE

The orifice installed at this location is part of the calibrated exhaust system.

r. Simultaneously tighten handknobs on handler until enough space is obtained between flanges to remove seal. Do not remove orifice.

s. Install test plate 9010860-11 from test plate kit 9016710-11 on flange and aline with bolts.

t. Simultaneously loosen handknobs on handler until bellows is fully extended.

CAUTION

Excessive movement of the HO1 instrumentation line can change the torque of the line adapter at the antiflood check valve, causing leakage past the seal.

u. Install a minimum of 10 bolts, washers, and nuts from test plate kit 9016710-11 and the two HO1 line support clips to secure test plate 9019860-11. Torque nuts to 36-40 in-lb.

3.3.4 REMOVING EXHAUST SYSTEM TEST PLATES FROM STAGE-INSTALLED ENGINE.

Operation	Result
a. Increase pressure to OTBV closing control (test plate 9020251-11) to 400 ±25 psig.	OTBV closes.

NOTE

Steps b through j remove the test plate and reinstall the seal at the OTBV flange.

b. Remove nuts and washers from valve attaching bolts.

c. Rotate hex extension of lower bracket until enough clearance is obtained between thrust chamber exhaust manifold and valve flange to allow removal of test plate.

d. Withdraw attaching bolts just enough to allow test plate removal; remove test plate.

CAUTION

Joint connected in steps e through h cannot be leak tested, therefore condition and security of joints (section II) must be inspected and inspection recorded by each of two persons.

e. Install seal and secure with attaching bolts. Do not install nuts on attaching bolts at this time.

f. Rotate hex of valve removal tool until bellows is extended.

g. Install washers and nuts on attaching bolts, and remove tool brackets. Do not torque nuts at this time.

h. Install remaining attaching bolts, washers, and nuts. Cross-torque nuts to 76-84 in-lb. Obtain verification of acceptable condition and security of joint (section II) by each of two persons.

i. Decrease pressure to test plate 0020251-11 to zero. If test plate EWR225307 is installed, vent engine pneumatic system, then proceed with step k.

Operation	Result
j. Open bleed valve on test plate 0020251-11.	Closing control pressure vents, and OTBV opens. OTBV may not open completely, since opening control pressure is not applied.

CAUTION

Excessive movement of the HO1 instrumentation line can change the torque of the line adapter at the anti-flood check valve, causing leakage past the seal.

NOTE

Steps k through p remove the test plate and reinstall the heat exchanger duct flange seal.

k. Remove nuts and washers from flange bolts and remove bolts.

l. Simultaneously tighten handknobs of handler enough to remove test plate 0019860-11; remove test plate.

CAUTION

Joint connected in steps m through o cannot be leak tested, therefore condition and security of joints (section II) must be inspected and inspection recorded by each of two persons.

1A. Verify that orifice is installed.

m. Install bolts removed from flange during exhaust system test plates installation (paragraph 3.3.3) and install seal. Do not install nuts at this time.

n. Simultaneously loosen handknobs of handler until bellows is fully extended.

o. Install washers and nuts on attaching bolts. Torque nuts to 76-84 in-lb. Obtain verification of acceptable condition and security of joint (section II) by each of two persons.

p. Remove handler.

pA. If orifice identification tag was removed, safetywire tag around flange using lockwire MS20995N.

pB. If the orifice identification tag is damaged or lost, emboss a new 1/2-wide strip of aluminum, CRES, or zinc with orifice part numbers and orifice size (3/32-inch high numbers). Check that the orifice part number and size agree with the Engine Log Book entry. Safetywire new orifice identification tag around flange using lockwire MS20995N.

q. Disconnect test hose from test plate on OTBV closing control port. Remove test plate.

r. Install new seal, and connect closing control line. Torque bolts to 31-45 in-lb, and safetywire.

s. Remove test plate between OTBV opening control and opening control port. Reinstall orifice with cupped side toward OTBV. Install new seal, and connect opening control line. Torque bolts to 41-45 in-lb, and safetywire.

t. Disconnect test hose, and remove adapter from torque access of fuel turbine exhaust duct.

CAUTION

Joint connected in step u cannot be leak tested, therefore condition and security of joints (section II) must be inspected and inspection recorded by each of two persons.

u. Reinstall seal and plug in torque access of fuel turbine exhaust duct. Torque plug to 405-445 in-lb. Obtain verification of acceptable condition and security of joint (section II) by each of two persons.

3.3.5 MEASURING PRESSURE IN ELECTRICAL CONTROL ASSEMBLY AND PRIMARY AND AUXILIARY FLIGHT INSTRUMENTATION PACKAGES. This procedure lists equipment required and step-by-step instructions for measuring pressure in the ECA and the primary and auxiliary FI packages. See figure 3-94 for Engine Log Book entry requirements.

WARNING

Spark Ignitor Cable Pressurization Tool Kit 0025425 must be operated by authorized personnel trained in the use of the equipment.

3.3.5.1 Preparing for Test.

a. Obtain the following test equipment, or equivalent.

(1) Pressure adapter 9019530-21, adapter 9019535, pressure gage 19-9019533, crowfoot wrench 9019552, pressure cap 9025515, one packing MS28778-4, and 2 packings MS28778-2 from spark igniter cable pressurization toolkit 9025425-21 or 9025425-31.

(2) Leak-test compound (MIL-L-25567, Type I).

(3) A strap-on temperature measuring device accurate within 2° F.

NOTE

If test equipment has previously been assembled proceed to step e.

b. Install pressure gage 19-9019533 with packing MS28778-2 on adaptor 9019535; torque to 25-35 in-lb.

c. Install pressure cap 9025515 with packing MS28778-4 on adaptor 9019535; torque to 25-35 in-lb.

d. Connect pressure adaptor 9019530-21 to adaptor 9019535 with packing MS28778-2; torque to 25-35 in-lb.

e. Pressurize assembled adapter to 25 ±2 psig with gaseous nitrogen and leak test adapter with leak-test compound. Leakage is not allowable.

f. Install strap-on temperature measuring device on face plate of ECA or FI package.

g. Torque pressurizing valve to 200 ±10 in-lb or verify that pressurizing valve has previously been torqued to 200 ±10 in-lb. (Apply torque to 3/4-inch hex portion of valve, not to 5/8-inch swivel nut.)

CAUTION

Removing, installing, or tightening adapter 9019530-21 on the ECA or FI package pressurizing valve when the pressurizing valve swivel nut is not torqued to 100 ±5 in-lb can damage the pressurizing valve.

h. Verify that pressurizing valve swivel nut is torqued to 100 ±5 in-lb. Do not loosen swivel nut.

i. Remove pressurizing valve cap from ECA or FI package to be tested. Inspect cap for evidence of damage to cap seal. If seal is unsatisfactory, install new cap after completion of testing.

j. Turn core depressor (on adaptor 9019530-21) fully counterclockwise. (See figure 3-34.)

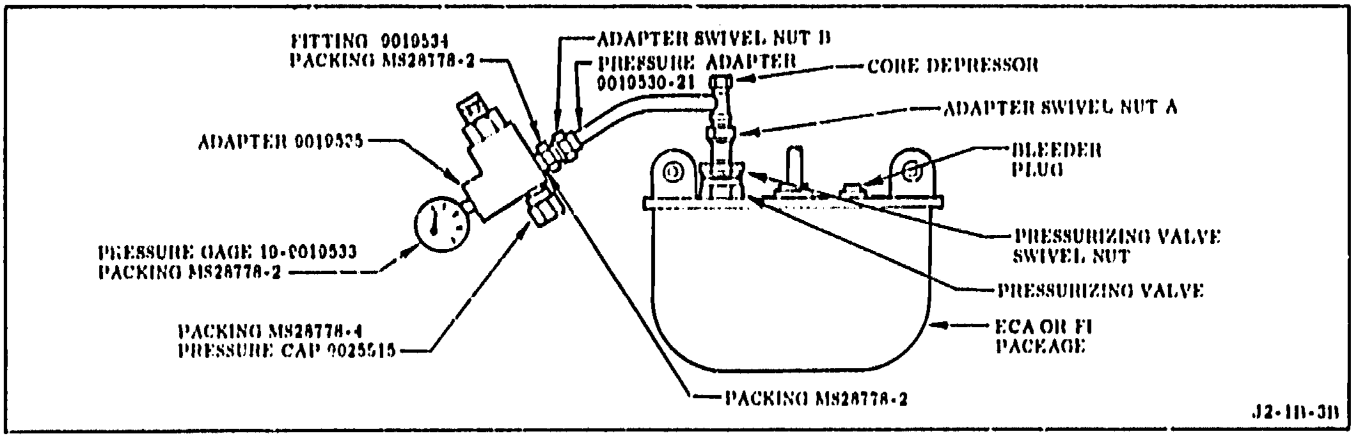


Figure 3-34. Measuring Pressure in Electrical Control Assembly and Flight Instrumentation Packages

Figure 3-35 deleted.

CAUTION

Overtorquing swivel nut A can damage the seal and/or pressurizing valve.

NOTE

Contact of the adapter seal with the pressurizing valve stem can be felt by supporting the weight of the adapter and manually turning adapter swivel nut A.

k. Install adapter 9019530-21 on pressurizing valve. Support weight of adapter while finger-tightening adapter swivel nut A. (See figure 3-34.) Torque adapter swivel nut A 1/2 to one turn past point that adapter seal contacts pressurizing valve stem.

l. Verify by visual inspection that sufficient clearance exists between adapter 9019530-21 and pressurizing valve swivel nut to allow backing off pressurizing valve swivel nut 1-2 turns (approximately 2 threads showing between adapter and swivel nut). If proper clearance cannot be obtained, remove adapter and replace adapter seal 9025517 as outlined in R-3825-5.

NOTE

When the pressure gage is in other than a vertical position, the indicator needle may be off-zero.

m. Record off-zero position of pressure gage indicator needle for use in future gage readings.

3.3.5.2 Measuring Pressure.

CAUTION

Overtorquing the core depressor can damage the pressurizing valve and/or adapter.

a. Manually turn core depressor clockwise (do not use wrench) until depressor bottoms (indicated by increased torque required to turn core depressor). Do not overtorque depressor.

b. If an immediate pressure increase of approximately 1.5 psig is indicated on gage, loosen pressure cap 9025515 and vent adapter. (This pressure increase is an indication of pressure trapped between valve core and metal-to-metal seat.) Torque pressure cap 9025515 to 25-35 in-lb while holding adapter 9019535 to prevent applying a load on adapter 9019530-21.

c. Monitor pressure gage for a minimum of 5-6 minutes. If a pressure increase is indicated on gage, pressurizing valve metal-to-metal seat is leaking. If leakage exists, complete pressure-measuring procedure and replace pressurizing valve as outlined in R-3825-3. Leak test and pressurize ECA or FI package as outlined in paragraphs 3.3.5A and 3.3.5B.

d. Using crowfoot wrench 9019552, open pressurizing valve by backing off valve swivel nut 1-2 full turns while holding valve. Make allowance for any off-zero position of gage indicator needle, and record pressure for future reference.

Operation	Result
e. Leak-test joints and fittings of adapter and gage. If no leakage exists, proceed to step g. If leakage exists, close pressurizing valve by torquing swivel nut to 100 ±5 in-lb, and repair leakage.	Leakage is not allowable.

f. Using crowfoot wrench 9019552, open pressurizing valve by backing off valve swivel nut 1-2 full turns while holding valve. Make allowance for any off-zero position of gage indicator needle, and record pressure for future reference.

g. Read temperature indicated on strap-on temperature measuring device. Using pressure recorded in step d or f, convert measured pressure (P_1) to temperature-corrected pressure (P_t) through the following equation:

$$P_t = \frac{(530)\,(P_1 + 14.7)}{T + 460} - 14.7$$

where

P_t = temperature corrected pressure (psig)

P_1 = measured pressure (psig)

T = measured temperature (°F)

(3) If point where lines cross is in SPECIAL DISPOSITION REQUIRED range, contact Engine Contractor for evaluation and disposition.

(4) If point where lines cross is in ACCEPTABLE pressure range, proceed to step s.

s. Using crowfoot wrench 9019552, close pressurizing valve by torquing valve swivel nut to 55-60 in-lb.

sA. Turn core depressor on adapter 0019530-21 to fully counterclockwise position.

Operation	Result
t. Remove pressure gage 10-0019533 and adapter 0019535 from fitting 0019534.	Locked up pressure in gage and adapter will vent.

u. Using packing MS28778-2, install union AN815-2J in fitting 0019534; torque to 25-35 in-lb.

v. Make sure adapter 0019530-21 is positioned on ECA or FI package pressurizing valve so that leak-test compound cannot enter adapter tube when applied to open end of union AN815-2J. If necessary, reposition adapter as follows:

(1) Loosen adapter 0019530-21 from ECA or FI package pressurizing valve by backing off adapter swivel nut A. (See figure 3-34.)

(2) Position adapter 0019530-21 so that adapter tube is in a down position.

NOTE

Contact of the adapter seal with the pressurizing valve stem can be felt by supporting the adapter and manually turning adapter swivel nut A.

(3) Tighten adapter swivel nut A (figure 3-34) 1/2 to one full turn after adapter seal contacts pressurizing valve stem. Do not exceed one full turn of adapter swivel nut A after seal contacts pressurizing valve stem.

h. Locate time (in months) on curve in figure 1-8D since ECA or FI package was last pressurized or repressurized. (Refer to Engine Log Book.) Project this time and temperature-corrected pressure obtained in step g until lines cross.

(1) If point where lines cross is in range requiring leak test, leak-test as outlined in paragraph 3.3.5A. If leak testing does not determine cause of low pressure, contact Engine Contractor for disposition.

(2) If point where lines cross is in REPRESSURIZE range, repressurize ECA or FI package as outlined in paragraph 3.3.5B.

(3) If point where lines cross is in SPECIAL DISPOSITION REQUIRED range, contact Engine Contractor for evaluation and disposition.

(4) If point where lines cross is in ACCEPTABLE pressure range, proceed to step i.

i. Using crowfoot wrench 0019552, close pressurizing valve by torquing valve swivel nut to 100 ±5 in-lb.

j. Turn core depressor on adapter 0019530-21 to fully counterclockwise position.

k. Loosen pressure cap 0025516 on adapter 0019535. After pressure has vented from adapter, torque pressure cap to 25-35 in-lb while holding adapter 0019535 to prevent applying a load on adapter 0019530-21.

l. Using crowfoot wrench 0019552, open pressurizing valve by backing off valve swivel nut 1-2 full turns while holding valve. Monitor pressure gage for 5-6 minutes. If a pressure increase in excess of 0.3 psi is indicated on gage, replace valve core as outlined in steps m through s. If leakage is not excessive, proceed to step t.

m. Using crowfoot wrench 0019552, close pressurizing valve by torquing valve swivel nut to 100 ±5 in-lb.

n. Remove adapter from pressurizing valve by backing off adapter swivel nut A.

o. Using adapter EWR183648, remove valve core.

p. Verify that pressurizing valve stem contains a 1-3/8 inch minimum depth hole for core pin clearance. If depth of hole is not 1-3/8 inch, replace pressurizing valve as outlined in R-3825-3. Leak-test and pressurize ECA or FI package as outlined in paragraphs 3.3.5A and 3.3.5B.

q. Purge core cavity by momentarily backing off valve swivel nut and opening valve metal-to-metal seat.

r. Clean new valve core as outlined in R-3825-3, and install core using torque adapter EWR183648. Torque valve core to 24 ±5 in-oz.

s. Repressurize ECA or FI package as outlined in paragraph 3.3.5B.

t. Using crowfoot wrench 0019552, close pressurizing valve by torquing valve swivel nut to 100 ±5 in-lb.

u. Manually turn core depressor clockwise (do not use wrench) until depressor bottoms (indicated by increased torque required to turn core depressor). Do not overtorque depressor.

v. Loosen pressure cap 0025516 on adapter 0019535. After pressure has vented from adapter, torque pressure cap to 25-35 in-lb while holding adapter 0019535 to prevent applying a load on adapter 0019530-21.

w. Monitor pressure gage for a minimum of 5-6 minutes. If a pressure increase is indicated on gage, pressurizing valve metal-to-metal seat is leaking. If leakage exists, replace pressurizing valve as outlined in R-3825-3. Leak test and pressurize ECA or FI package as outlined in paragraphs 3.3.5A and 3.3.5B.

x. Turn core depressor on adapter 0019530-21 to fully counterclockwise position. Remove adapter from pressurizing valve, and install valve cap. Torque to 20-25 in-lb, and safetywire.

y. Replace all used packings on test equipment with new packings, and return test equipment to pressurization toolkit.

z. Remove strap-on temperature measuring device.

3.3.5A LEAK-TESTING ELECTRICAL CONTROL ASSEMBLY AND FLIGHT INSTRUMENTATION PACKAGES. The following lists the test equipment required and a step-by-step procedure for leak-testing the ECA and primary and auxiliary FI packages (figure 3-36). See figure 3-94 for Engine Log Book entry requirements. If specified results are not obtained when performing this test, refer to figure 3-36A for trouble analysis. In the following procedure, when removing, installing, or tightening adapter 0019530-31 or the pressurizing valve cap on the pressurizing valve, the pressurizing valve swivel nut must be torqued to 100 ±5 in-lb.

WARNING

Spark Igniter Cable Pressurization Tool Kit 9025425 must be operated by authorized personnel trained in the use of the equipment.

CAUTION

Removing, installing, or tightening adapter 0019530-31 or the pressurizing valve cap on the pressurizing valve when the valve swivel nut is not torqued to 100 ±5 in-lb can damage the pressurizing valve.

NOTE

The ECA may be leak tested with electrical power applied if spark exciters and engine control circuits are not energized when the ECA is under vacuum.

3.3.5A.1 Preparing for Test.

a. Obtain the following test equipment, or equivalent:

(1) Helium leak detector set and test port station from components adapter set 0010700, or equivalent.

(2) Pressure adapter 0019530-31 and crowfoot wrench 0019552 from pressurization toolkit 0025425-31.

(3) Hypodermic needle (A. S. Aloe Co), 27 gage, 5/8 inch long, or equivalent.

(4) A low-pressure, regulated source of helium. (Refer to section II.)

b. Prepare helium leak detector set and test port station for test as outlined in R-3825-5. After calculating leak detector sensitivity, maintain leak detector set in a test-ready condition.

c. Torque pressurizing valve to 200 ±10 in-lb or verify that pressurizing valve has previously been torqued to 200 ±10 in-lb. (Apply torque to 3/4-inch hex portion of valve, not to 5/8-inch swivel nut.)

d. Remove cap from pressurizing valve of ECA or FI package. Inspect cap for evidence of damage to cap seal. If seal is unsatisfactory, install new cap at completion of testing.

NOTE

Contact of the adapter seal with the pressurizing valve stem can be felt by supporting the adapter and manually turning adapter swivel nut A.

e. Rotate core depressor on adapter 0019530-31 fully counterclockwise. Connect adapter to pressurizing valve on ECA or FI package, and tighten adapter swivel nut A (figure 3-36) 1/2 to one full turn after adapter seal contacts valve stem. Do not exceed one full turn of adapter swivel nut A after seal contacts pressurizing valve stem.

f. Connect test port station to pressure adapter 0019530-31, and initiate vacuum pumping of system.

g. If contamination and/or leakage rate of pressurizing system exceeds 3×10^{-7} cc helium per second when helium leak detector test light comes on, isolate leak detector, repair leak, and/or clean test system, and repeat system test.

3.3.5A.2 Leak-Testing.

a. Using crowfoot wrench 0019552, back off ECA or FI package pressurizing valve swivel nut 1-2 full turns while holding valve to prevent loosening.

CAUTION

Overtorquing the core depressor can damage the valve core and/or depressor.

b. Depress valve core in pressurizing valve by manually rotating core depressor (do not use wrench) on adapter 0019530-31 clockwise until depressor or valve core bottoms. Do not overtorque depressor.

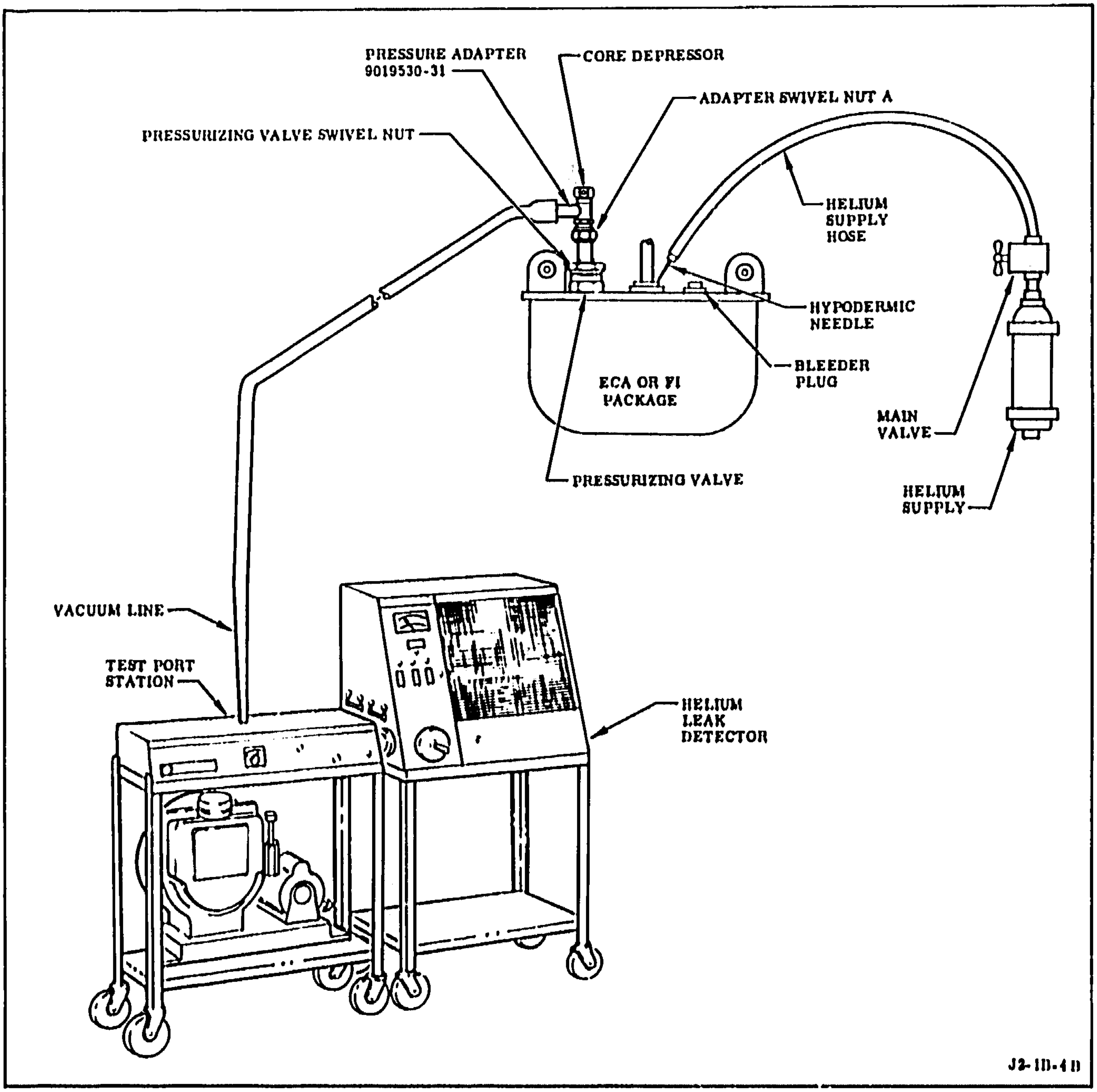


Figure 3-36. Leak-Testing Electrical Control Assembly and Flight Instrumentation Packages

WARNING

A sudden burst of pressure to the helium supply hose can blow the hypodermic needle from the hose, causing serious injury to personnel and damage to equipment.

c. Connect hypodermic needle to a low-pressure, regulated source of helium (refer to section II), and slowly open helium main valve until helium flows from needle.

d. After helium leak detector returns to test condition, proceed to step e if ECA is under test or to step f if FI package is under test.

Operation	Result
e. Observe helium leak detector for indication of leakage while flowing helium with hypodermic needle, around the following areas. If leakage does not exceed maximum allowable leakage, proceed to step g. If total leakage exceeds maximum allowable leakage, see figure 3-36A for trouble analysis.	Maximum total allowable ECA leakage is 6×10^{-6} cc of helium per second.

NOTE

Excess leakage in this procedure is the cumulative (total) leakage of substeps 1 through 5.

(1) ECA cover seal.

(2) Each electrical connector.

(3) Each exciter.

(4) Bleeder plug.

(5) Pressurizing valve.

Operation	Result
f. Observe helium leak detector for indication of leakage while flowing helium with hypodermic needle, around the following areas. If leakage does not exceed maximum allowable leakage, proceed to step g. If total leakage exceeds maximum allowable leakage, see figure 3-36A for trouble analysis.	Maximum total allowable FI package leakage is 6×10^{-6} cc of helium per second.

NOTE

Excess leakage in this procedure is the cumulative (total) leakage of substeps 1 through 4.

(1) Bleeder plug and pressurizing valve.

(2) FI package cover seal.

(3) Each electrical connector.

(4) Each transducer.

g. Isolate leak detector from system.

h. Using crowfoot wrench 0019552, close ECA or FI package pressurizing valve by torquing pressurizing valve swivel nut to 100 ±5 in-lb.

i. Turn core depressor on adaptor 0019530-31 fully counterclockwise, and remove adaptor from pressurizing valve by backing off adaptor swivel nut A.

j. Secure helium leak detector as outlined in R-3825-5 and return to components adaptor set 0016790.

k. Pressurize ECA and/or FI packages as soon as possible. (Refer to paragraph 3.3.5B.)

Trouble	Probable Cause	Isolation Procedure	Remedy
1. Total leakage exceeds 6×10^{-6} cc helium per second when flowing helium around ECA or FI package cover plate sealing area.	Seal leaking.	None required.	Replace ECA or FI package. (Refer to R-3825-3.)
2. Total leakage exceeds 6×10^{-6} cc helium per second when flowing helium around ECA or FI package electrical connectors.	Seal leaking.	None required.	Replace ECA or FI package. (Refer to R-3825-3.)
3. Total leakage exceeds 6×10^{-6} cc helium per second when flowing helium around exciters.	Seal leaking.	None required.	Replace ECA. (Refer to R-3825-3.)
4. Total leakage exceeds 6×10^{-6} cc helium per second when flowing helium around ECA or FI package bleeder plug.	Seal leaking.	None required.	a. Isolate leak detector. b. Remove bleeder plug and discard packing. c. Lubricate (Method J) new packing with lubricant grease RB0140-012 (Rocketdyne), and install bleeder plug. (Bleeder plug may be replaced or reinstalled.) Torque bleeder plug to 100-120 in-lb, and safetywire. d. Initiate vacuum pumping of system and repeat leak test of bleeder plug (refer to paragraph 3.3.5A).
5. Total leakage exceeds 6×10^{-6} cc helium per second when flowing helium around ECA or FI package pressurizing valve.	Seal leaking.	None required.	a. Isolate leak detector. b. Using crowfoot wrench 9019552, close valve by torquing pressurizing valve locknut to 100 ±5 in-lb.

Figure 3-36A. ECA and FI Packages Leak-Test Trouble Analysis Chart (Sheet 1 of 3)

Trouble	Probable Cause	Isolation Procedure	Remedy
5. (cont)			c. Remove adapter from pressurizing valve by turning core depressor on adapter fully counterclockwise and backing off adapter swivel nut A. d. Replace pressurizing valve. (Refer to R-3825-3.) NOTE Contact of the adapter seal with the pressurizing valve stem can be felt by supporting the adapter and manually turning adapter swivel nut A. e. Install adapter 9019530-31 (still connected to leak detector) on ECA pressurizing valve, and tighten adapter swivel nut A 1/2 to one full turn after adapter seal contacts valve stem. Do not exceed one full turn after seal contacts pressurizing valve stem. CAUTION Overtorquing the core depressor can damage the valve core and/or depressor. f. Depress valve core in pressurizing valve by hand-turning core depressor (do not use wrench) on adapter 9019530-31 clockwise until depressor or valve core bottoms (indicated by increased torque required to turn depressor). Do not overtorque depressor.

Figure 3-36A. ECA and FI Packages Leak-Test Trouble Analysis Chart (Sheet 2 of 3)

Trouble	Probable Cause	Isolation Procedure	Remedy
5. (cont)			g. Using crowfoot wrench 9019552, open pressurizing valve by backing off pressurizing valve swivel nut 1-2 full turns while holding valve to prevent loosening.
			h. Initiate vacuum pumping of system, and repeat pressurizing valve leak test (refer to paragraph 3.3.5A).
6. Total leakage exceeds 6×10^{-6} cc helium per second when flowing helium around each transducer on FI package.	Seal leaking.	None required.	Install new transducer seal as outlined in R-3825-3, and repeat leak test (refer to paragraph 3.3.5A).

Figure 3-36A. ECA and FI Packages Leak-Test Trouble Analysis Chart (Sheet 3 of 3)

3.3.5B <u>PRESSURIZING ELECTRICAL CONTROL ASSEMBLY AND FLIGHT INSTRUMENTATION PACKAGES.</u> The following lists the test equipment required and a step-by-step procedure for pressurizing the ECA and primary and auxiliary FI packages (figures 3-37 and 3-38). See figure 3-94 for Engine Log Book entry requirements. In the following procedure, when removing, installing, or tightening adapter 9019530-21 or the pressurizing valve cap on the pressurizing valve, the pressurizing valve swivel nut must be torqued to 100 ±5 in-lb.

CAUTION

Removing, installing, or tightening adapter 9019530-21 or the pressurizing valve cap on the ECA or FI package pressurizing valve when the valve swivel nut is not torqued to 100 ±5 in-lb can damage the pressurizing valve.

3.3.5B.1 <u>Preparing for Pressurization.</u>

a. Obtain the following test equipment, or equivalent:

(1) Pressurizing manifold 9025801, swivel 19-9025513, adapter 9019535, pressure adapter 9019530-21, fitting 9019534 (removed from pressure adapter 9019530-21), pressure cap 9025515, pressure gage 19-9019533, 3 packings MS28778-2, 2 packings MS28778-4, crowfoot wrench 9019552 from spark igniter cable pressurization toolkit 9025425-21 or 9025425-31, and adapter EWR183648.

(2) A regulated source of gaseous nitrogen (refer to section II) capable of supplying 30 psig to ECA or FI package.

(3) A strap-on temperature measuring device accurate within 2° F.

b. Install strap-on temperature measuring device on face plate of ECA or FI package.

c. Remove adapter 19-9025800 (if installed) from end of pressurizing manifold hose, and using packing MS28778-4, install swivel 19-9025513 on hose; torque to 25-35 in-lb.

d. Support pressurizing manifold by strapping it to engine near ECA or FI package under test.

NOTE

If test equipment has previously been assembled proceed to step k.

e. Using 2 packings MS28778-2, install pressure gage 19-9019533 and fitting 9019534 on adapter 9019535. Torque gage and fitting to 25-35 in-lb.

f. Using packing MS28778-4, install adapter gage and fitting (assembled in step e) on pressurizing manifold hose; torque to 25-35 in-lb.

g. Using packing MS28778-2, install adapter 9019530-21 on fitting 9019534 (installed on adapter 9019535). Torque adapter swivel nut B (figure 3-37) to 25-35 in-lb.

h. Close PUMP VALVE and VENT valve, and open PRESS VALVE on pressurizing manifold.

i. Connect pressurizing line from GN_2 supply to PRESS port of pressurizing manifold.

j. Make sure pressure regulator on GN_2 supply is closed; then open main valve on GN_2 supply.

k. Hold pressurizing manifold hose to prevent whipping, and apply a low-pressure purge to hose by slowly opening pressure regulator in pressurizing line. Purge hose for 1-2 minutes. Close pressure regulator.

l. Torque pressurizing valve to 200 ±10 in-lb or verify that pressurizing valve has previously been torqued to 200 ±10 in-lb. (Apply torque to 3/4-inch hex portion of valve, not to 5/8-inch swivel nut.)

m. Remove cap from ECA or FI package pressurizing valve. Inspect cap for evidence of damage to cap seal. If seal is unsatisfactory, install new cap at completion of testing.

NOTE

Contact of the adapter seal with the pressurizing valve stem can be felt by supporting the adapter and manually turning adapter swivel nut A.

n. Rotate core depressor on adapter 9019530-21 fully counterclockwise. Connect adapter to ECA or FI package pressurizing valve, and tighten adapter swivel nut A (figure 3-37) 1/2 to one full turn after adapter seal contacts valve stem. Do not exceed one full turn of adapter swivel nut A after seal contacts pressurizing valve stem. Position adapter and pressure gage so that gage can be read easily.

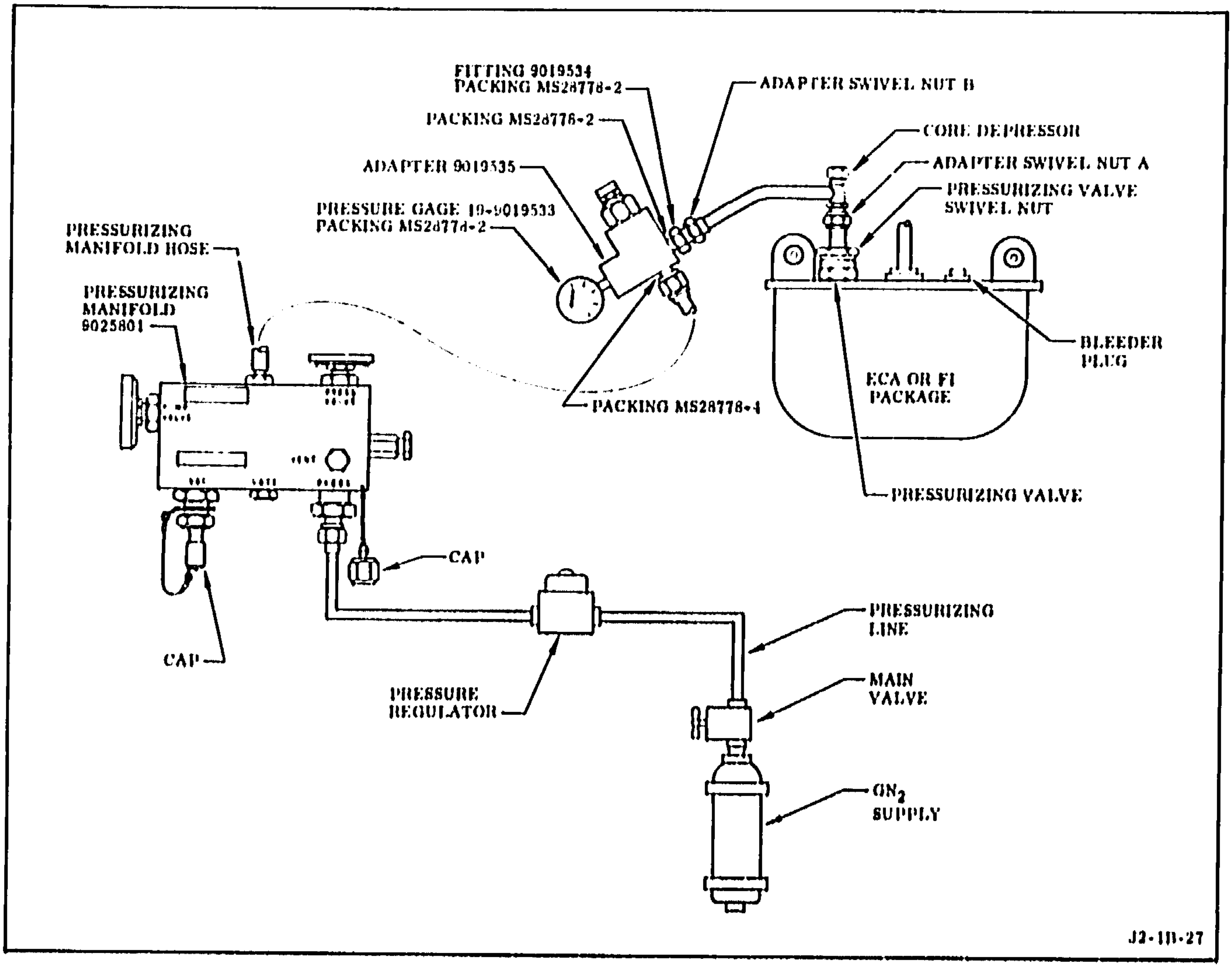


Figure 3-37. Pressurizing Electrical Control Assembly and Flight Instrumentation Packages

o. Support adapter 9019530-21 to prevent rotation and to prevent damaging adapter tube.

p. Read indication on temperature measuring device on ECA or FI package. Using indicated temperature, see figure 3-38 and determine required ECA or FI package pressure.

NOTE

When the pressure gage is in other than a vertical position, the indicator needle may be off-zero.

q. Record off-zero indication of pressure gage 10-9019533 for future reference. Adjust pressure regulator in GN_2 pressurizing line until pressure gage 10-9019533 indicates ±0.5 psi of required pressure determined in step p. Make allowance for off-zero indication of gage, if any.

3.3.5B.2 Pressurizing.

CAUTION

Overtorquing the core depressor can damage the valve core and/or depressor.

a. Hand-turn core depressor (do not use wrench) on adapter 9019530-21 until depressor or valve core bottoms (indicated by increased torque required to turn core depressor). Do not overtorque depressor.

Ambient Temperature (°F)	Component Pressure (psig)	Ambient Temperature (°F)	Component Pressure (psig)
40	22.8	73	25.2
41	22.8	74	25.3
42	22.9	75	25.4
43	23.0	76	25.4
44	23.0	77	25.5
45	23.1	78	25.6
46	23.2	79	25.7
47	23.3	80	25.7
48	23.3	81	25.8
49	23.4	82	25.9
50	23.5	83	26.0
51	23.6	84	26.0
52	23.6	85	26.1
53	23.7	86	26.2
54	23.8	87	26.3
55	23.9	88	26.3
56	23.9	89	26.4
57	24.0	90	26.5
58	24.1	91	26.6
59	24.2	92	26.6
60	24.2	93	26.7
61	24.3	94	26.8
62	24.4	95	26.9
63	24.5	96	26.9
64	24.5	97	27.0
65	24.6	98	27.1
66	24.7	99	27.2
67	24.8	100	27.2
68	24.8	101	27.3
69	24.9	102	27.4
70	25.0	103	27.5
71	25.1	104	27.5
72	25.1	105	27.6

Figure 3-38. Required Pressure Versus Hardware Temperature

b. Using crowfoot wrench 9019552, open ECA or FI package pressurizing valve by backing off pressurizing valve swivel nut 1-2 full turns while holding valve to prevent loosening.

c. Maintain pressure for 10 ±0.5 minutes. Make allowance for off-zero indication of gage, and adjust pressure in ECA or FI package to ±0.5 psi of required pressure (determined in paragraph 3.3.5B.1).

d. Using crowfoot wrench 9019552, close ECA or FI package pressurizing valve by torquing pressurizing valve swivel nut (figure 3-37) to 100 ±5 in.-lb.

e. Record package pressure (step c) in Engine Log Book.

f. Close main valve on GN_2 supply and pressure regulator in pressurizing line.

g. Disconnect pressurizing manifold hose from adapter 9019535 and install packing MS28778-4 and pressure cap 9025515 on adapter. Torque cap to 25-35 in-lb while holding adapter 9019535 to prevent applying a load on adapter 9019530-21.

h. Turn core depressor on adapter 9019530-21 fully counterclockwise.

i. Using crowfoot wrench 9019552, open pressurizing valve by backing off valve swivel nut 1-2 full turns while holding valve. Monitor pressure gage for 5-6 minutes. If a pressure increase in excess of 0.3 psi is indicated on gage, replace valve core as outlined in steps j through p. If leakage is not excessive, proceed to step q.

j. Using crowfoot wrench 9019552, close pressurizing valve by torquing valve swivel nut to 100 ±5 in-lb.

k. Remove adapter from pressurizing valve by backing off adapter swivel nut A.

l. Using adapter EWR183648, remove valve core.

m. Verify that pressurizing valve stem contains a 1-3/8 inch minimum depth hole for core pin clearance. If depth of hole is not 1-3/8 inch, replace pressurizing valve as outlined in R-3825-3. Leak-test ECA or FI package as outlined in paragraph 3.3.5A.

n. Purge core cavity by momentarily backing off valve swivel nut and opening valve metal-to-metal seat.

o. Clean new valve core as outlined in R-3825-3, and install core using torque adapter EWR183648. Torque valve core to 24 ±5 in-oz.

p. Repressurize ECA or FI package and leak-test new core by repeating step i.

q. Using crowfoot wrench 9019552, close pressurizing valve by torquing valve swivel nut to 100 ±5 in-lb.

r. Manually turn core depressor clockwise (do not use wrench) until depressor bottoms (indicated by increased torque required to turn core depressor). Do not overtorque depressor.

s. Loosen pressure cap 9025515 on adapter 9019535. After pressure has vented from adapter, torque pressure cap to 25-35 in-lb while holding adapter 9019535 to prevent applying a load on adapter 9019530-21.

t. Monitor pressure gage for a minimum of 5-6 minutes. If a pressure increase is indicated on gage, pressurizing valve metal-to-metal seat is leaking. If leakage exists, replace pressurizing valve as outlined in R-3825-3. Leak test and pressurize ECA or FI package as outlined in paragraphs 3.3.5A and 3.3.5B.

u. Turn core depressor on adapter 9019530-21 fully counterclockwise.

v. Remove adapter from pressurizing valve by backing off adapter swivel nut A.

w. Install valve cap on ECA or FI package pressurizing valve. Torque to 20-25 in-lb, and safetywire.

x. Disconnect pneumatic supply from pressurizing manifold, remove manifold from engine, replace all used packings on test equipment with new packings, and return test equipment to pressurization toolkit.

3.3.6 <u>MEASURING PRESSURE IN SPARK IGNITER CABLES.</u> See figure 3-94 for Engine Log Book entry requirements.

WARNING

Spark Igniter Cable Pressurization Tool Kit 9025425 must be operated by authorized personnel trained in the use of the equipment.

3.3.6.1 Preparing for Test.

a. Obtain the following test equipment, or equivalent:

(1) Pressure adapter 9019530-21, adapter 9019535, pressure gage 19-9019533, crowfoot wrench 9019552, pressure cap 9025515, one packing MS28778-4, and 2 packings MS28778-2 from spark igniter cable pressurization toolkit 9025425-21 or 9025425-31, and adapter EWR183648.

(2) A strap-on temperature measuring device accurate within 2° F.

b. Install strap-on temperature measuring device on face plate of ECA.

NOTE

If test equipment has previously been assembled proceed to step f.

c. Install pressure gage 19-9019533 with packing MS28778-2 on adapter 9019535; torque to 25-35 in-lb.

d. Install pressure cap 9025515 with packing MS28778-4 on adapter 9019533; torque to 25-35 in-lb.

e. Connect pressure adapter 9019530-21 to adapter 9019535 with packing MS28778-2; torque to 25-35 in-lb.

f. Pressurize assembled adapter to 25 ±2 psig with gaseous nitrogen and leak test adapter with leak-test compound. Leakage is not allowable.

g. Torque spark igniter cable pressurizing boss jamnut to 290 ±10 in-lb or verify that jamnut has previously been torqued to 290 ±10 in-lb. Use backup wrench to hold pressurizing boss to prevent rotation during torquing.

h. Torque pressurizing valve to 200 ±10 in-lb or verify that pressurizing valve has previously been torqued to 200 ±10 in-lb. (Apply torque to 3/4-inch hex portion of valve, not to 5/8-inch swivel nut.) Use backup wrench to hold pressurizing boss to prevent rotation during torquing.

CAUTION

Removing, installing, or tightening adapter 9019530-21 on the SIC pressurizing valve when the pressurizing valve swivel nut is not torqued to 100 ±5 in-lb can damage the pressurizing valve.

i. Verify that pressurizing valve swivel nut is torqued to 100 ±5 in-lb. Do not loosen swivel nut.

j. Remove cap from pressurizing valve on cable being tested. All other caps must be left installed at all times. Inspect cap for evidence of damage to cap seal. If seal is unsatisfactory, install new cap at completion of testing.

3.3.6.2 Measuring Pressure.

CAUTION

Overtorquing swivel nut A can damage the seal and/or pressurizing valve.

NOTE

Adapter seal contact with the valve stem can be felt if the adapter weight is supported while swivel nut A is tightened.

a. Rotate core depressor fully counterclockwise, and install adapter 9019530-21 on pressurizing valve. Support weight of adapter while fingertightening adapter swivel nut A. (See figure 3-39.) Torque adapter swivel nut A 1/2 to one turn past point that adapter seal contacts pressurizing valve stem.

b. Verify by visual inspection that sufficient clearance exists between adapter 9019530-21 and pressurizing valve swivel nut to allow backing off pressurizing valve swivel nut 1-2 turns (approximately 2 threads showing between adapter and swivel nut). If proper clearance cannot be obtained, remove adapter and replace adapter seal 9025517 as outlined in R-3825-5.

NOTE

When the pressure gage is in other than a vertical position, the indicator needle may be off-zero.

c. Record position of gage indicator needle for future reference.

d. Manually turn core depressor clockwise (do not use wrench) until depressor bottoms (indicated by increased torque required to turn core depressor). Do not overtorque depressor.

e. If an immediate pressure increase of approximately 1.5 psig is indicated on gage, loosen pressure cap 9025515 and vent adapter. (This pressure increase is an indication of pressure trapped between valve core and metal-to-metal seal.) Torque pressure cap 9025515 to 25-35 in-lb while holding adapter 9019535 to prevent applying a load on adapter 9019530-21.

k. Open valve core by manually rotating core depressor (do not use wrench) clockwise until valve core of depressor bottoms. Do not overtorque depressor. If a pressure increase is indicated on gage, the pressurizing valve metal-to-metal seat is leaking. If leakage exists, complete pressure measuring procedure and then replace pressurizing valve (refer to R-3825-3). Leak-test and repressurize SIC as outlined in paragraphs 3.3.6.1 and 3.3.6.2.

kA. Manually turn core depressor to fully counterclockwise position. Back off pressurizing valve swivel nut 1-2 full turns while holding valve. If a pressure is indicated on gage, valve core is leaking. If leakage exists, complete pressure-measuring procedure, then replace valve core after closing pressurizing valve metal-to-metal seat. (Refer to R-3825-3.)

kB. Using crowfoot wrench 9019552, close pressurizing valve. Do not tighten over 60 in-lb. Manually turn core depressor clockwise (do not use wrench) until depressor bottoms (indicated by increased torque required to turn core depressor). Do not overtorque depressor.

WARNING

Excessive pressure in the SIC can blow the glass from the pressure gage when the valve is opened, causing injury to personnel.

l. Open pressurizing valve by slowly backing off valve swivel nut 1-2 turns while holding valve to prevent valve from loosening. Wear a face shield and stand to one side of gage face when opening valve. If gage pressure reaches or exceeds 30 psi, close pressurizing valve by torquing pressurizing valve swivel nut to 55-60 in-lb, and perform steps m through o. If pressure on gage does not reach 30 psi, proceed to step p.

f. Monitor pressure gage for a minimum of 5-6 minutes. If a pressure increase is indicated on gage, pressurizing valve metal-to-metal seat is leaking. If leakage exists, complete pressure-measuring procedure and replace pressurizing valve as outlined in R-3825-3. Leak test and pressurize spark igniter cable as outlined in paragraphs 3.3.6A and 3.3.6B.

WARNING

Excessive pressure in the SIC can blow the glass from the pressure gage when the valve is opened, causing injury to personnel.

g. Open pressurizing valve by slowly backing off valve swivel nut 1-2 turns while holding valve to prevent valve from loosening. Wear a face shield and stand to one side of gage face when opening valve. If gage pressure reaches or exceeds 30 psi, close pressurizing valve by torquing pressurizing valve swivel nut to 100 ±5 in-lb, and perform steps h through j. If pressure on gage does not reach 30 psi, proceed to step k.

h. Turn core depressor on pressure adapter fully counterclockwise, and remove adapter from pressurizing valve by backing off adapter swivel nut A. Do not vent pressure from SIC.

i. Install cap on SIC pressurizing valve. Torque cap to 20-25 in-lb.

j. Obtain sample of pressurant from each overpressurized (30 psig or more) SIC. (Refer to paragraph 3.3.7.)

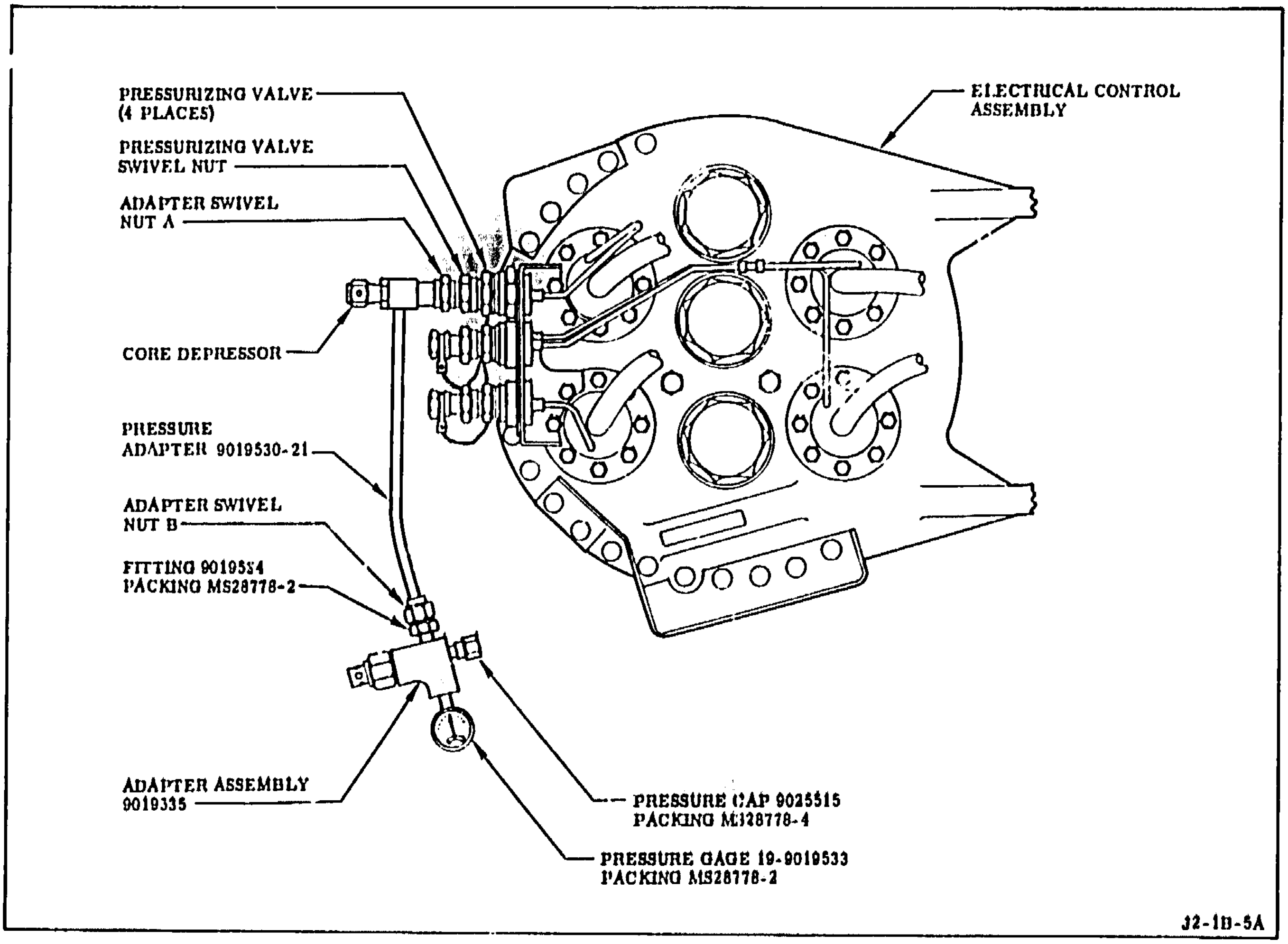


Figure 3-39. Measuring Spark Igniter Cable Pressure

Figure 3-40 deleted.

k. If gage pressure does not reach 30 psi, allow a minimum of 2 minutes for pressure to stabilize, making allowance for any off-zero position of gage indicator needle. If gage pressure indicates a continuous decrease instead of stabilization, close pressurizing valve and leak-test test equipment; then repeat test. Record gage pressure for future reference.

l. Using crowfoot wrench 9019552, close pressurizing valve by torquing valve swivel nut to 100 ±5 in-lb.

m. Read temperature indicated on strap-on temperature measuring device on ECA. Using pressure recorded in step k, convert measured pressure (P_1) to temperature-corrected pressure (P_t) through the following equation:

$$P_t = \frac{(530)\,(P_1 + 14.7)}{T + 460} - 14.7$$

where

P_t = temperature-corrected pressure (psig)

P_1 = measured pressure (psig)

T = measured temperature (°F)

mA. When performing 15-day pressure measurement on spark igniter cables where it is known that pressure is transferring between cable and ignition exciter, perform step mB. On other spark igniter cables, proceed to step n.

mB. Using temperature-corrected pressure obtained in step m, determine if pressure drop was greater than 3.0 psig. If pressure drop was greater than 3.0 psig, repressurize cable and continue measuring pressure and repressurizing cable every 15 days until it is determined that cable pressure will not leak down to less than 5.0 psig at time of scheduled launch, plus 5 days. If pressure reading was less than 2.5 psig, leak-test cable (refer to paragraph 3.3.6A). If pressure drop was less than 3.0 psig, repressurize cable and continue 12-month scheduled monitor tests as outlined in section I.

n. Locate time (in months) on curve of figure 1-8E since SIC was last pressurized. (Refer to Engine Log Book.) Project this time and temperature-corrected pressure obtained in step m until lines cross. Determine required action as follows:

(1) If point where lines cross is in range requiring leak test, leak test as outlined in paragraph 3.3.6A. If leak testing does not determine cause of low pressure or if it is determined that pressure is transferring between cable and ignition exciter, repressurize spark igniter cable (paragraph 3.3.6B) and repeat pressure measurement in 15 days as specified in step mB.

(2) If point where lines cross is in REPRESSURIZE range, repressurize SIC as outlined in paragraph 3.3.6B.

(3) If point where lines cross is in SPECIAL DISPOSITION REQUIRED range, leak-test SIC and then contact Engine Contractor for evaluation and disposition.

(4) If point where lines cross is in ACCEPTABLE PRESSURE range, proceed to step o.

o. Turn core depressor on adapter 9019530-21 to fully counterclockwise position.

p. Loosen pressure cap 9025615 on adapter 9019535. After pressure has vented from adapter, torque pressure cap to 25-35 in-lb while holding adapter 9019535 to prevent applying a load on adapter 9019530-21.

q. Using crowfoot wrench 9019552, open pressurizing valve by backing off valve swivel nut 1-2 full turns while holding valve. Monitor pressure gage for 5-6 minutes. If a pressure increase in excess of 0.3 psi is indicated on gage, replace valve core as outlined in steps r through x. If leakage is not excessive, proceed to step y.

r. Using crowfoot wrench 9019552, close pressurizing valve by torquing valve swivel nut to 100 ±5 in-lb.

s. Remove adapter from pressurizing valve by backing off adapter swivel nut A.

t. Using adapter EWR183648, remove valve core.

u. Verify that pressurizing valve stem contains a 1-3/8 inch minimum depth hole for core pin clearance. If depth of hole is not 1-3/8 inch, replace pressurizing valve as outlined in R-3825-3. Leak-test and repressurize spark igniter cable as outlined in paragraphs 3.3.6A and 3.3.6B.

v. Purge core cavity by momentarily backing off valve swivel nut and opening valve metal-to-metal seat.

w. Clean new valve core as outlined in R-3825-3, and install core using torque adapter EWR183648. Torque valve core to 24 ±5 in-oz.

x. Repressurize spark igniter cable as outlined in paragraph 3.3.6B.

y. Using crowfoot wrench 9019552, close pressurizing valve by torquing valve swivel nut to 100 ±5 in-lb.

z. Manually turn core depressor clockwise (do not use wrench) until depressor bottoms (indicated by increased torque required to turn core depressor). Do not overtorque depressor.

aa. Loosen pressure cap 9025515 on adapter 9019535. After pressure has vented from adapter, torque pressure cap to 25-35 in-lb while holding adapter 9019535 to prevent applying a load on adapter 9019530-21.

ab. Monitor pressure gage for a minimum of 5-6 minutes. If a pressure increase is indicated on gage, pressurizing valve metal-to-metal seat is leaking. If leakage exists, replace pressurizing valve as outlined in R-3825-3. Leak test and pressurize spark igniter cable as outlined in paragraphs 3.3.6A and 3.3.6B.

ac. Turn core depressor on adapter 9019530-21 fully counterclockwise, and remove adapter from pressurizing valve by backing off adapter swivel nut A.

ad. Install valve cap on SIC pressurizing valve. Torque to 20-25 in-lb, and safetywire.

ae. Replace all used packings on test equipment with new packings, and return test equipment to pressurization toolkit.

3.3.6A <u>LEAK-TESTING SPARK IGNITER CABLES</u>. The following lists the test equipment required and a step-by-step procedure for leak-testing SIC (figure 3-41). See figure 3-94 for Engine Log Book entry requirements. If specified results are not obtained when performing this test, refer to figure 3-41A for trouble analysis. In the following procedure, when removing, installing, or tightening adapter 9019530-31 or the SIC pressurizing valve cap on the SIC pressurizing valve, the pressurizing valve swivel nut must be torqued to 100 ±5 in-lb.

WARNING

Spark Igniter Cable Pressurization Tool Kit 9025425 must be operated by authorized personnel trained in the use of the equipment.

CAUTION

Removing, installing, or tightening adapter 9019530-31 or the SIC pressurizing valve cap on the SIC pressurizing valve when the valve swivel nut is not torqued to 100 ±5 in-lb can damage the pressurizing valve.

- The spark exciters must not be energized with the spark igniter cable under vacuum. Energizing the spark exciters with cable under vacuum could cause an arc and damage cable or spark exciter.

3.3.6A.1 <u>Preparing for Test.</u>

a. Obtain the following test equipment, or equivalent:

(1) Helium leak detector set and test port station from components adapter set 9016796, or equivalent.

(2) Pressure adapter 9019530-31 and crowfoot wrench 9019552 from spark igniter cable pressurization toolkit 9025425-31.

(3) Hypodermic needle (A. S. Aloe Co), 27 gage, 5/8 inch long, or equivalent.

(4) A low-pressure, regulated source of helium. (Refer to section II.)

(5) A regulated source of helium (refer to section II) capable of supplying 30 psig to THRUST CHAMBER JACKET PURGE and PURGE MANIFOLD SYSTEM customer connects.

(6) Test plate 9020222-11, 6 bolts AN4-17A, 12 washers LD153-0010-0009, 6 nuts NAS679A4W, and one packing MS29513-019, from test plate kit 9018843-11.

b. Prepare helium leak detector set and test port station for test as outlined in R-3825-5. After calculating leak detector sensitivity, maintain leak detector set in a test-ready condition.

c. Torque spark igniter cable pressurizing boss jamnut to 290 ±10 in-lb or verify that jamnut has previously been torqued to 290 ±10 in-lb. Use backup wrench to hold pressurizing boss to prevent rotation during torquing.

d. Torque pressurizing valve to 200 ±10 in-lb or verify that pressurizing valve has previously been torqued to 200 ±10 in-lb. (Apply torque to 3/4-inch hex portion of valve, not to 5/8-inch swivel nut.) Use backup wrench to hold pressurizing boss to prevent rotation during torquing.

e. Remove cap from SIC pressurizing valve. Inspect cap for evidence of damage to cap seal. If seal is unsatisfactory, install new cap at completion of testing.

f. Turn core depressor on adapter 9019530-31 fully counterclockwise. (See figure 3-41.)

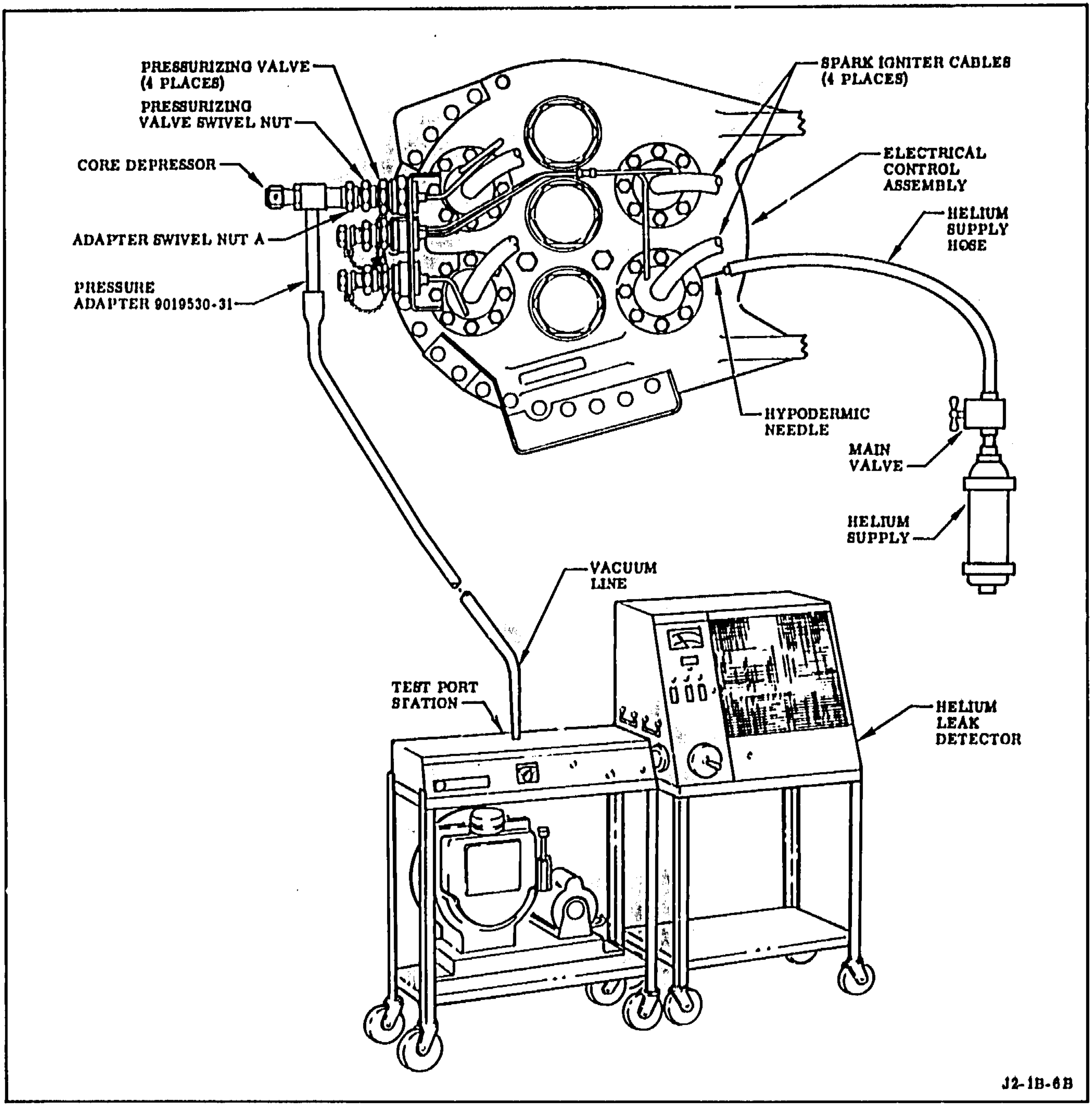


Figure 3-41. Leak-Testing Spark Igniter Cables

NOTE

Contact of the adapter seal with the pressurizing valve stem can be felt by supporting the adapter and manually turning adapter swivel nut A.

g. Install adapter 9019530-31 on SIC pressurizing valve and tighten adapter swivel nut A (figure 3-41) 1/2 to one full turn after adapter seal contacts pressurizing valve stem. Do not exceed one full turn after adapter seal contacts pressurizing valve stem.

h. Connect test port station to pressure adapter 9019530-31, and initiate vacuum pumping of system.

i. If contamination and/or leakage rate of pressurizing system exceeds 3 x 10^{-7} cc helium per second after helium leak detector returns to test condition, isolate leak detector, repair leak and/or clean test system, and repeat system test. If contamination and/or leakage rate does not exceed 3 x 10^{-7} cc helium per second, proceed to paragraph 3.3.6A.2.

3.3.6A.2 Leak-Testing.

CAUTION

Overtorquing the depressor can damage the valve core and/or depressor.

Operation	Result
a. Manually turn core depressor (do not use wrench) on adapter 9019530-31 clockwise until depressor or valve core bottoms (indicated by increased torque required to turn depressor). Do not overtorque depressor.	Helium leak detector must return to test condition within 2 minutes. Maximum allowable leakage is 3 x 10^{-7} cc helium per second.
b. Using crowfoot wrench 9019552, back off SIC pressurizing valve swivel nut 1-2 full turns while holding valve to prevent valve from loosening.	Helium leak detector must return to test condition within 30 minutes. Maximum allowable leakage is 3 x 10^{-7} cc helium per second.

c. Leak-test SIC spark plugs by purging helium around spark plug tips while observing helium leak detector for indication of leaks. The following method may be used; however, other methods are acceptable as long as a dense concentration of helium is maintained around SIC spark plug tips during leak test:

(1) Install test plate 9020222-11 using 6 bolts AN4-17A, 12 washers LD153-0010-0009, 6 nuts NAS679A4W, and one packing MS29513-010, on THRUST CHAMBER JACKET PURGE customer connect when leak-testing ASI cable spark plugs, and on PURGE MANIFOLD SYSTEM customer connect when leak-testing GG SIC spark plugs. (The stage purge supplies may be used to supply helium through the customer connects.)

(2) Connect a regulated source of helium (refer to section II) to test plate 9020222-11.

(3) Close shutoff valve downstream of helium supply pressure gage and regulator, and adjust regulator until gage indicates 30 ±0.5 psi.

(4) Remove one thrust chamber exit closure desiccant cover.

Operation	Result
(5) Open shutoff valve downstream of helium supply regulator to start helium purge. Observe helium leak detector for indication of leakage. Close helium supply shutoff valve to stop helium purge.	Maximum allowable leakage is 3 x 10^{-7} cc helium per second.

(6) Disconnect regulated helium source from test plate 9020222-11, and remove test plate from customer connect.

d. Connect hypodermic needle to low-pressure source of helium.

WARNING

A sudden burst of pressure to the helium supply hose can blow the hypodermic needle from the hose, causing serious injury to personnel and damage to equipment.

e. Slowly open helium supply main valve until a flow of helium is obtained from hypodermic needle.

Trouble	Probable Cause	Isolation Procedure	Remedy
1. Helium leak detector does not return to test condition within 2 minutes after depressing pressurizing valve core, or contamination and/or leakage rate exceeds 3×10^{-7} cc helium per second.	Pressurizing valve metal-to-metal seat leaking.	None required.	Replace pressurizing valve, and repeat leak test. (Refer to R-3825-3.)
2. Helium leak detector does not return to test condition after opening pressurizing valve.	Pressure transferring between SIC and spark exciter.	a. Using crowfoot wrench 9019552, close SIC pressurizing valve by torquing pressurizing valve swivel nut to 100 ±5 in-lb and rotating core depressor fully counterclockwise. b. Disconnect adapter from SIC pressurizing valve by backing off adapter swivel nut A. c. Remove SIC from ECA. (Refer to R-3825-3.) d. Seal open end of spark igniter cable bell housing with test plate 9022786 (obtain from components adapter set 9016796). e. Support SIC bell housing, pressurizing tube, and pressurizing valve.	None (acceptable condition).

Figure 3-41A. Spark Igniter Cable Leak-Test Trouble Analysis Chart (Sheet 1 of 4)

Trouble	Probable Cause	Isolation Procedure	Remedy
2. (cont)		f. Initiate vacuum pumping of disconnected SIC. g. Perform SIC leak test as outlined in paragraph 3.3.6A.2. At completion of an acceptable leak test, reconnect SIC as outlined in R-3825-3 and pressurize SIC as outlined in paragraph 3.3.6B. h. Using leak-test compound, leak-test SIC bell housing to ECA sealing area and pressurizing valve to valve boss. Leakage is not allowable.	
3. Contamination and/or leakage rate exceeds 3×10^{-7} cc helium per second after opening pressurizing valve.	Pressurizing valve O-ring seal leaking.	Observe helium leak detector for indication of leakage while flowing helium with hypodermic needle around SIC pressurizing valve.	Replace pressurizing valve and repeat leak test. (Refer to R-3825-3.)
4. Leakage exceeds 3×10^{-7} cc helium per second when purging around spark plug tips.	Spark igniter spark plug leaking.	None required.	Replace SIC. (Refer to R-3825-3.)
5. Total leakage of SIC exceeds 6×10^{-6} cc helium per second when flowing helium around cable bell housing to ECA sealing area.	O-ring seal leaking.	None required.	a. Disconnect SIC from ECA, and replace SIC bell housing O-ring. (Refer to R-3825-3.) b. Reconnect SIC to ECA. (Refer to R-3825-3.) c. Repeat leak test.

Figure 3-41A. Spark Igniter Cable Leak-Test Trouble Analysis Chart (Sheet 2 of 4)

Trouble	Probable Cause	Isolation Procedure	Remedy
6. Total leakage of SIC exceeds 6×10^{-6} cc helium per second when flowing helium around SIC pressurizing valve.	Pressurizing valve leaking.	None required.	a. Replace pressurizing valve. (Refer to R-3825-3.) b. Repeat leak test.
7. Total leakage of SIC exceeds 6×10^{-6} cc helium per second when flowing helium around pressurizing valve boss to tube weld.	Pressurizing valve boss to tube weld joint leaking.	None required.	a. Disconnect SIC from ECA. (Refer to R-3825-3.) b. Touch up weld using TIG (tungsten-arc inert-gas-shielded) process and 347 stainless-steel filler alloy. Make sure weld does not plug tube. c. Reconnect SIC to ECA. (Refer to R-3825-3.) d. Repeat leak test.
8. Total leakage of SIC exceeds 6×10^{-6} cc helium per second when flowing helium around SIC pressurizing tube-to-tube splice.	SIC pressurizing tube-to-tube splice leaking.	None required.	a. Disconnect SIC from ECA. (Refer to R-3825-3.) b. Touch up braze using gold-silver-copper-zinc brazing alloy RB0170-089 (Rocketdyne) and flux mixture of 50-percent Handy flux and 50-percent Handy flux, Type B1 (Handy and Harman). Make sure braze does not plug tube. c. Reconnect SIC to ECA. (Refer to R-3825-3.) d. Repeat leak test.
9. Total leakage of SIC exceeds 6×10^{-6} cc helium per second when flowing helium around pressurizing tube to bell housing connect point.	Pressurizing tube to bell housing weld joint leaking.	None required.	a. Disconnect SIC from ECA. (Refer to R-3825-3.)

Figure 3-41A. Spark Igniter Cable Leak-Test Trouble Analysis Chart (Sheet 3 of 4)

Trouble	Probable Cause	Isolation Procedure	Remedy
			b. On SIC NA5-27448 and NA5-27448T1, touch up weld using TIG (tungsten-arc inert-gas-shielded) process and ER308 filler alloy. Make sure weld does not plug tube. c. On SIC 651389, 651390, 651392-3, 651392-5, and 651393, use Strip Kleen No. 171 (Sinclair Paint Co), or equivalent, and remove zinc chromate primer from weld area. Touch up weld using TIG (tungsten-arc inert-gas-shielded) process and gold-nickel brazing alloy RB0170-064 (Rocketdyne), and apply a coat of zinc chromate primer (MIL-P-8585) to welded area. Make sure weld does not plug tube. d. Reconnect SIC to ECA. (Refer to R-3825-3.) e. Repeat leak test.
10. Total leakage of SIC exceeds 6×10^{-6} cc helium per second when flowing helium around SIC to bell housing braze joint.	Faulty braze joint.	None required.	Replace SIC. (Refer to R-3825-3.)
11. Total leakage of SIC exceeds 6×10^{-6} cc helium per second when flowing helium around SIC to spark plug braze joint.	Faulty braze joint.	None required.	Replace SIC. (Refer to R-3825-3.)
12. Total leakage of SIC exceeds 6×10^{-6} cc helium per second when flowing helium along entire length of SIC.	Hole in SIC bellows.	None required.	Replace SIC. (Refer to R-3825-3.)
13. Total leakage of SIC exceeds 6×10^{-6} cc helium per second when helium is injected under RTV tape sheathing.	Hole in SIC bellows.	None required.	Replace SIC. (Refer to R-3825-3.)

Figure 3-41A. Spark Igniter Cable Leak-Test Trouble Analysis Chart (Sheet 4 of 4)

Operation	Result
f. Observe helium leak detector for leakage while flowing helium with hypodermic needle, around the following areas:	Maximum total allowable SIC leakage is 6×10^{-6} cc helium per second.

NOTE

Excess leakage in this procedure is the cumulative (total) leakage of any one SIC exceeding 6×10^{-6} cc helium per second.

(1) SIC bell housing to ECA sealing area.

(2) SIC pressurizing valve.

(3) SIC pressurizing valve boss to tube weld.

(4) SIC pressurizing tube to tube splice.

(5) Pressurizing tube to bell housing connect point.

(6) SIC to bell housing braze joint, entire length of SIC and SIC to spark plug braze joint.

g. If leak test is being performed to isolate the cause of a cable low-pressure condition and excessive leakage was not detected in step f, do the following: Using a hypodermic needle, inject helium under the RTV tape sheating near the cable to bell housing joint while observing leak detector. Total leakage (leakage of step f and this step) must not exceed 6×10^{-6} cc helium per second.

h. Using crowfoot wrench 9019552, close SIC pressurizing valve by torquing valve swivel nut to 100 ±5 in-lb.

i. Turn core depressor on adapter 9019530-31 fully counterclockwise, and remove adapter from SIC pressurizing valve by backing off adapter swivel nut A.

j. Secure helium leak detector as outlined in R-3825-5.

k. Within one hour pressurize SIC (paragraph 3.3.6B).

3.3.6A1 LEAK-TESTING SPARK IGNITER CABLES WITH KNOWN IGNITION EXCITER LEAKAGE. Refer to Engine Log Book for identification of leaking ignition exciters. See figure 3-41 for connecting test equipment.

WARNING

Spark Igniter Cable Pressurization Tool Kit 9025425 must be operated by authorized personnel trained in the use of the equipment.

CAUTION

Removing, installing, or tightening adapter 9019530-31 or the SIC pressurizing valve cap on the SIC pressurizing valve when the valve swivel nut is not torqued to 100 ±5 in-lb can damage the pressurizing valve.

3.3.6A1.1 Preparing for Test.

a. Obtain the following test equipment, or equivalent:

(1) Helium leak detector set and test port station from components adapter set 9016796, or equivalent.

(2) Pressure adapter 9019530-31 and crowfoot wrench 9019552 from spark igniter cable pressurization toolkit 9025425-31.

(3) Hypodermic needle (A.S. Aloe Co), 27-gage, 5/8-inch long, or equivalent.

(4) A low-pressure, regulated source of helium. (Refer to section II.)

(5) A regulated source of helium (refer to section II) capable of supplying 30 psig to THRUST CHAMBER JACKET PURGE and PURGE MANIFOLD SYSTEM customer connects.

(6) Test plate 9020222-11, 6 bolts AN4-17A, 12 washers LD153-0010-0009, 6 nuts NAS679A4W, and one packing MS29513-019, from test plate kit 9018843-11.

b. Prepare helium leak detector set and test port station for test per manufacturer's requirements. After calculating leak detector sensitivity, maintain leak detector set in a test-ready condition.

c. Remove cap from SIC pressurizing valve. Inspect cap for evidence of damage to cap seal. If seal is damaged, install new cap at completion of testing.

d. Turn core depressor on adapter 9019530-31 fully counterclockwise. (See figure 3-41.)

NOTE

Contact of the adapter seal with the pressurizing valve stem can be felt by supporting the adapter and manually turning adapter swivel nut A.

e. Install adapter 9019530-31 on SIC pressurizing valve. Support weight of adapter while fingertightening adapter swivel nut A (figure 3-41) 1/2 to one full turn after adapter seal contacts pressurizing valve stem. Do not exceed one full turn after adapter seal contacts pressurizing valve stem.

f. Connect test port station to pressure adapter 9019530-31, and initiate vacuum pumping of system.

g. If contamination and/or leakage rate of pressurizing system exceeds 3×10^{-7} cc helium per second after helium leak detector returns to test condition, isolate leak detector, repair leak and/or clean test system, and repeat system test. If contamination and/or leakage rate does not exceed 3×10^{-7} cc helium per second, proceed to paragraph 3.3.6A1.2.

3.3.6A1.2 Leak-Testing.

CAUTION

Overtorquing the depressor can damage the valve core and/or depressor.

Operation	Result
a. Manually turn core depressor (do not use wrench) on adapter 9019530-31 clockwise until depressor or valve core bottoms (indicated by increased torque required to turn depressor). Do not overtorque depressor.	Helium leak detector must return to test condition within 2 minutes. Maximum allowable leakage is 3×10^{-7} cc helium per second. Leakage in excess of 3×10^{-7} indicates pressurizing valve metal-to-metal seat is leaking.

b. Using crowfoot wrench 9019552, back off SIC pressurizing valve swivel nut 1-2 full turns while holding valve to prevent valve from loosening.

Operation	Result
c. Continue vacuum pumping of system for 30 minutes. Record actual contamination/leakage rate value.	Helium leak detector contamination and/or leakage rate must be on scale (less than 1×10^{-4} cc helium per second).

d. Leak-test SIC spark plugs by purging helium around spark plug tips while observing helium leak detector for indication of leaks. The following method may be used; however, other methods are acceptable if a dense concentration of helium is maintained around SIC spark plug tips during leak test.

(1) Install test plate 9020222-11 using 6 bolts AN4-17A, 12 washers LD153-0010-0009, 6 nuts NAS670A4W, and one packing MS29513-010, on THRUST CHAMBER JACKET PURGE customer connect when leak-testing ASI cable spark plugs, and on PURGE MANIFOLD SYSTEM customer connect when leak-testing GG SIC spark plugs. (The stage purge supplies may be used to supply helium through the customer connects.)

(2) Connect a regulated source of helium (refer to section II) to test plate 9020222-11.

(3) Close shutoff valve downstream of helium supply pressure gage and regulator, and adjust regulator until gage indicates 30 ±0.5 psi.

(4) Remove one thrust chamber exit closure desiccant cover.

Operation	Result
(5) Open shutoff valve downstream of helium supply regulator to start helium purge. Observe helium leak detector for indication of leakage. Close helium supply shutoff valve to stop helium purge.	Helium leak detector contamination and/or leakage rate must not increase above recorded value.

(6) Disconnect regulated helium source from test plate 9020222-11, and remove test plate from customer connect.

e. Connect hypodermic needle to low-pressure source of helium.

WARNING

A sudden burst of pressure to the helium supply hose can blow the hypodermic needle from the hose, causing serious injury to personnel and damage to equipment.

f. Slowly open helium supply main valve until a flow of helium is obtained from hypodermic needle.

Operation	Result
g. Observe helium leak detector for leakage while flowing helium with hypodermic needle, around the following areas:	Helium leak detector contamination and/or leakage rate must not increase above recorded value.
(1) SIC bell housing to ECA sealing area.	
(2) SIC pressurizing valve.	
(3) SIC pressurizing valve boss to tube weld.	
(4) SIC pressurizing tube to tube splice.	
(5) Pressurizing tube to bell housing connect point.	
(6) SIC to bell housing braze joint, entire length of SIC and SIC to spark plug braze joint.	

h. Using crowfoot wrench 9010552, close SIC pressurizing valve by torquing valve swivel nut to 100 ±5 in-lb.

i. Turn core depressor on adapter 9019530-31 fully counterclockwise, and remove adapter from SIC pressurizing valve by backing off adapter swivel nut A.

j. Secure helium leak detector as outlined in R-3825-5.

k. Within one hour pressurize SIC (paragraph 3.3.6B).

l. After pressurizing cable, measure pressure every 15 days minimum (refer to paragraph 3.3.6). Repressurize cable if pressure drop is greater than 3.0 psig. Perform leak-test of paragraph 3.3.6A if pressure reading is less than 2.5 psig.

m. Continue measuring pressure and repressurizing cable every 15 days until it is determined that cable pressure will not leak down to less than 5.0 psig at time of scheduled launch plus 5 days.

3.3.6B PRESSURIZING SPARK IGNITER CABLES. The following lists the test equipment required and a step-by-step procedure for pressurizing the SIC (figure 3-42). See figure 3-94 for Engine Log Book entry requirements. In the following procedure when removing, installing, or tightening adapter 9010530-21 or the SIC pressurizing valve cap on the SIC pressurizing valve, the pressurizing valve swivel nut must be torqued to 100 ±5 in-lb.

WARNING

Spark Igniter Cable Pressurization Tool Kit 9025425 must be operated by authorized personnel trained in the use of the equipment.

CAUTION

Removing, installing, or tightening adapter 9010530-21 or the SIC pressurizing valve cap when the valve swivel nut is not torqued to 100 ±5 in-lb can damage the pressurizing valve.

3.3.6B.1 Preparing for Pressurization.

a. Obtain the following test equipment, or equivalent:

(1) Pressure adapter 9010530-21, pressurizing manifold 9025801, swivel 10-9025513, fitting 9010534 (removed from pressure adapter 9010530-21), pressure gage 10-9019533, adapter 9010536, pressure cap 9025515, 3 packings MS28778-2, 3 packings MS28778-4, crowfoot wrench 9010552 from spark igniter cable pressurization toolkit 9025425-21 or 9025425-31, and adapter EWR183648.

(2) A regulated source of gaseous nitrogen (MIL-P-27401) capable of supplying 30 psig to SIC.

(3) A strap-on temperature-measuring device accurate within 2° F.

b. Install strap-on temperature-measuring device on face plate of ECA.

c. Remove adapter 10-9025800 (if installed) from end of pressurizing manifold hose, and using packing MS28778-4, install swivel 10-9025513 on hose; torque to 25-35 in-lb.

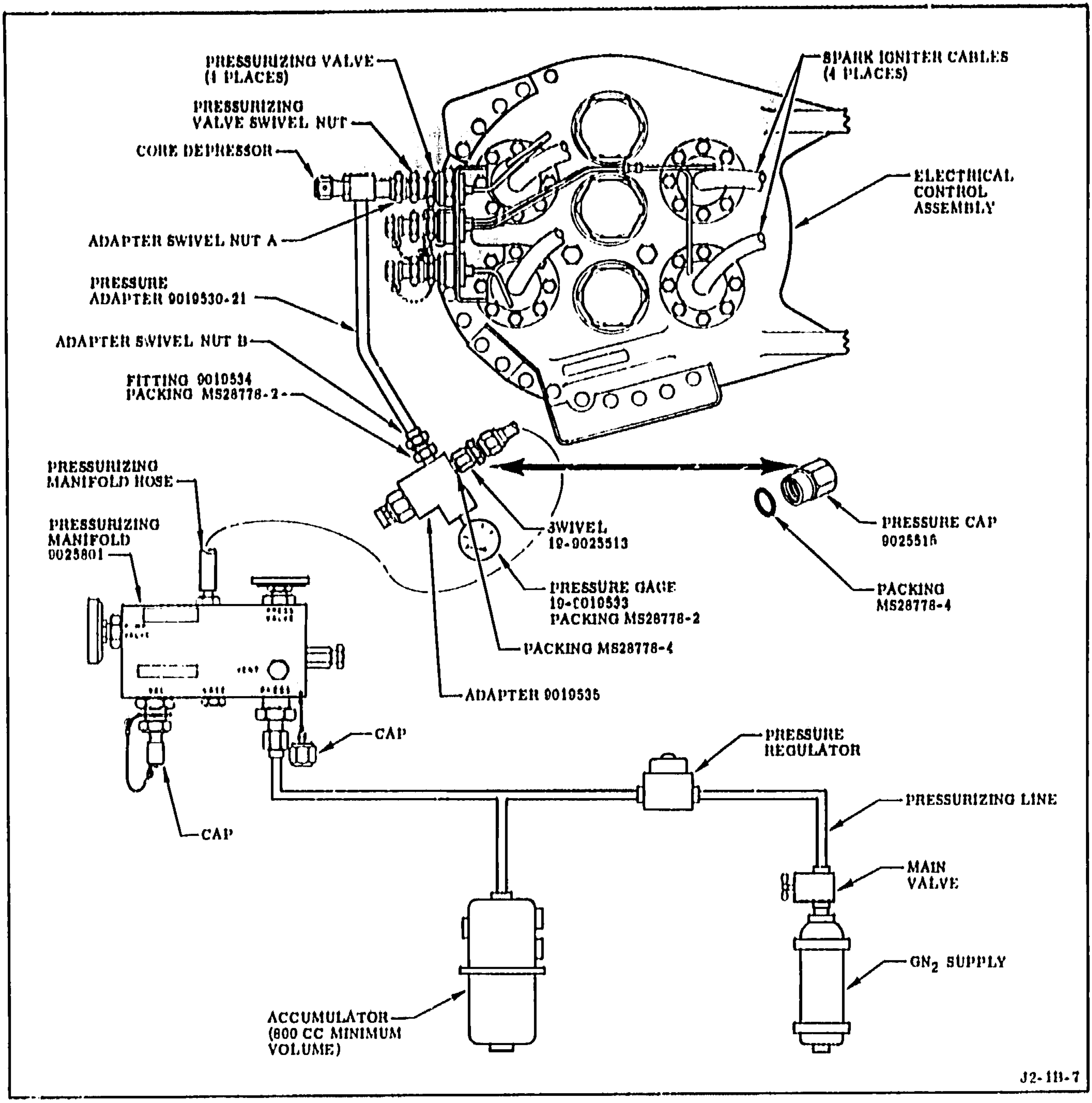


Figure 3-42. Pressurizing Spark Igniter Cables

d. Support pressurizing manifold by strapping it to engine near SIC pressurizing valves.

NOTE

If test equipment has previously been assembled proceed to step h.

e. Using 2 packings MS28778-2, install pressure gage 19-0019533 and fitting 0019534 on adapter 0019535. Torque gage and fitting to 25-35 in-lb.

f. Using packing MS28778-4, install adapter, gage, and fitting (assembled in step e) on pressurizing manifold hose; torque to 25-35 in-lb.

g. Using packing MS28778-2, install adapter 0019530-21 on fitting 0019534 (installed on adapter 0019535). Torque adapter swivel nut B (figure 3-42) to 25-35 in-lb.

h. Close PUMP VALVE and VENT valve, and open PRESS VALVE on pressurizing manifold.

i. Connect pressurizing line from GN_2 supply to PRESS port of pressurizing manifold.

j. Make sure pressure regulator on GN_2 supply is closed; then open main valve on GN_2 supply.

k. Hold pressurizing manifold hose to prevent whipping, and apply low-pressure purge to hose by slowly opening pressure regulator in pressurizing line. Purge pressurizing manifold and hose for 1-2 minutes. Close pressure regulator.

l. Torque spark igniter cable pressurizing boss jam nut to 200 ±10 in-lb or verify that jam nut has previously been torqued to 200 ±10 in-lb. Use backup wrench to hold pressurizing boss to prevent rotation during torquing.

m. Torque pressurizing valve to 200 ±10 in-lb or verify that pressurizing valve has previously been torqued to 200 ±10 in-lb. (Apply torque to 3/4-inch hex portion of valve, not to 5/8-inch swivel nut.) Use backup wrench to hold pressurizing boss to prevent rotation during torquing.

n. Remove cap rom SIC pressurizing valve. Inspect cap for evidence of damage to cap seal. If seal is unsatisfactory, install new cap at completion of pressurizing.

CAUTION

Bending the pressurizing manifold hose to a radius of less than 3 inches can damage the metal bellows of the hose.

NOTE

Contact of the adapter seal with the pressurizing valve stem can be felt by supporting the adapter and manually turning adapter swivel nut A.

- When the pressure gage is in other than a vertical position, the indicator needle may be off-zero.

o. Rotate core depressor on adapter 0019530-21 fully counterclockwise. Connect adapter to SIC pressurizing valve, and tighten swivel nut A (figure 3-42) 1/2 to one full turn after adapter seal contacts valve stem. Do not exceed one full turn after seal contacts pressurizing valve stem. Position adapter and pressure gage for easy reading of gage.

p. Support adapter 0019530-21 to prevent rotating and to prevent damage to adapter tube.

q. Read indication on temperature measuring device. Using indicated temperature and figure 3-43, determine required SIC pressure.

WARNING

Applying pressure in excess of 30 psi to the pressure gage can result in injury to personnel and damage to the gage.

r. Record off-zero indication of pressure gage 19-0019533 for future reference. Adjust pressure regulator in GN_2 pressurizing line until pressure gage indicates 0.5 psi of pressure determined in step q. Do not exceed 30 psig. Make allowance for any off-zero indication of gage.

Ambient Temperature (°F)	Component Pressure (psig)	Ambient Temperature (°F)	Component Pressure (psig)
40	25.3	73	27.7
41	25.3	74	27.8
42	25.4	75	27.9
43	25.5	76	27.9
44	25.5	77	28.0
45	25.6	78	28.1
46	25.7	79	28.2
47	25.8	80	28.2
48	25.8	81	28.3
49	25.9	82	28.4
50	26.0	83	28.5
51	26.1	84	28.5
52	26.1	85	28.6
53	26.2	86	28.7
54	26.3	87	28.8
55	26.4	88	28.8
56	26.4	89	28.9
57	26.5	90	29.0
58	26.6	91	29.1
59	26.7	92	29.1
60	26.7	93	29.2
61	26.8	94	29.3
62	26.9	95	29.4
63	27.0	96	29.4
64	27.0	97	29.5
65	27.1	98	29.6
66	27.2	99	29.7
67	27.3	100	29.7
68	27.3	101	29.8
69	27.4	102	29.9
70	27.5	103	30.0
71	27.6	104	30.0
72	27.6		

Figure 3-43. Required Spark Igniter Cable Pressure Versus Hardware Temperature

Operation	Result

CAUTION

Allowing leak-test compound to contact the burst diaphragm disk can damage the disk.

Operation	Result
s. Using leak-test compound, leak-test all connections on pressurizing system. Do not allow leak-test compound to contact burst diaphragm disk.	Leakage is not allowable.

CAUTION

Overtorquing the core depressor can damage the valve core and/or depressor.

3.3.6B.2 Pressurizing.

a. Manually turn core depressor (do not use wrench) on adapter 9019530-21 clockwise until depressor or valve core bottoms (indicated by increased torque required to core depressor). Do not overtorque depressor.

b. Using crowfoot wrench 9019552, open SIC pressurizing valve by backing off pressurizing valve swivel nut 1-2 full turns while holding valve to prevent valve from loosening.

c. Maintain pressure for 10 ±0.5 minutes. Make allowance for any off-zero indication of gage, and adjust pressure in SIC to ±0.5 psig of required pressure. Do not exceed 30 psig.

d. Using crowfoot wrench 9019552, close SIC pressurizing valve by torquing pressurizing valve swivel nut to 100 ±5 in-lb. Turn core depressor on adapter 9019530-21 fully counterclockwise.

dA. On spark igniter cable NA5-27448T1, record gage reading from step c and measured hardware temperature for entry in Engine Log Book at completion of procedure.

e. Close main valve and pressure regulator on GN_2 supply, and open VENT valve on pressurizing manifold to vent trapped pressure.

f. Disconnect pressurizing manifold hose from adapter 9019535.

NOTE

On spark igniter cables 651389, 651390, or NA5-27448, perform a communication check (ability of cable to accept pressure) as outlined in steps g through m. Perform this test only during the first pressurization following spark igniter cable connection to the ECA.

g. Using packing MS28778-4, install pressure cap 9025515 on pressurizing connector of adapter 9019535. Torque pressure cap to 25-35 in-lb while holding adapter 9019535 to prevent adapter from applying a load on adapter 9019530-21.

CAUTION

Overtorquing the core depressor can damage the valve core and/or depressor.

h. Manually turn core depressor on adapter 9019530-21 clockwise until depressor or valve core bottoms (indicated by increased torque required to turn depressor). Do not overtorque depressor.

i. Using crowfoot wrench 9019552, back off pressurizing valve swivel nut 1-2 full turns while holding valve to prevent valve from loosening.

Operation	Result

CAUTION

Allowing leak-test compound to contact the burst diaphragm disk can damage the disk.

Operation	Result
j. Apply leak-test compound to all connections and fittings on adapter 9019530-21. If leakage exists, repair leakage and repressurize cable. Do not allow leak-test compound to contact burst diaphragm disk.	Leakage is not allowable.

k. Observe gage reading for 10 ±0.5 minutes. If stabilized gage reading is within 3 psi of adjusted pressure in step c, igniter cable is acceptable. If gage reading is more than 3 psi below adjusted pressure in step c, igniter cable pressure is unacceptable; repair igniter cable 651389 or 651390 (refer to R-3825-3); remove and replace igniter cable NA5-27448 (refer to R-3825-3).

l. If spark igniter cable is acceptable, record final pressure gage reading from step k and hardware temperature for entry in Engine Log Book at completion of procedure.

m. Using crowfoot wrench 9019552, close igniter cable pressurizing valve by torquing pressurizing valve swivel nut to 100 ±5 in-lb.

n. Turn core depressor on adapter 9019530-21 to fully counterclockwise position.

o. Loosen pressure cap 9025515 on adapter 9019535. After pressure has vented from adapter, torque pressure cap to 25-35 in-lb while holding adapter 9019535 to prevent applying a load on adapter 9019530-21.

p. Using crowfoot wrench 9019552, open pressurizing valve by backing off valve swivel nut 1-2 full turns while holding valve. Monitor pressure gage for 5-6 minutes. If a pressure increase in excess of 0.3 psi is indicated on gage, replace valve core as outlined in steps q through w. If leakage is not excessive, proceed to step x.

q. Using crowfoot wrench 9019552, close pressurizing valve by torquing valve swivel nut to 100 ±5 in-lb.

r. Remove adapter from pressurizing valve by backing off adapter swivel nut A.

s. Using adapter EWR183648, remove valve core.

t. Verify that pressurizing valve stem contains a 1-3/8 inch minimum depth hole for core pin clearance. If depth of hole is not 1-3/8 inch, replace pressurizing valve as outlined in R-3825-3. Leak-test spark igniter cable as outlined in paragraph 3.3.6A.

u. Purge core cavity by momentarily backing off valve swivel nut and opening valve metal-to-metal seat.

v. Clean new valve core as outlined in R-3825-3, and install core using torque adapter EWR183648. Torque valve core to 24 ±5 in-oz.

w. Repressurize spark igniter cable and leak-test new valve core by repeating step p.

x. Using crowfoot wrench 9019552, close pressurizing valve by torquing valve swivel nut to 100 ±5 in-lb.

y. Manually turn core depressor clockwise (do not use wrench) until depressor bottoms (indicated by increased torque required to turn core depressor). Do not overtorque depressor.

z. Loosen pressure cap 9025515 on adapter 9019535. After pressure has vented from adapter, torque pressure cap to 25-35 in-lb while holding adapter 9019535 to prevent applying a load on adapter 9019530-21.

aa. Monitor pressure gage for a minimum of 5-6 minutes. If a pressure increase is indicated on gage, pressurizing valve metal-to-metal seat is leaking. If leakage exists, replace pressurizing valve as outlined in R-3825-3. Leak test and pressurize spark igniter cable as outlined in paragraphs 3.3.6A and 3.3.6B.

ab. Turn core depressor on adapter 9019530-21 fully counterclockwise, and remove adapter from pressurizing valve by backing off adapter swivel nut A.

ac. Install valve cap on igniter cable pressurizing valve. Torque to 20-25 in-lb, and safetywire.

ad. Disconnect GN_2 supply from pressurizing manifold, and remove manifold from engine.

ae. Replace all used packings on test equipment with new packings, and return test equipment to pressurization toolkit.

3.3.7. SAMPLING PRESSURIZING GAS IN SPARK IGNITER CABLES AND ELECTRICAL CONTROL ASSEMBLY. When measuring pressure in spark igniter cables (SIC), if an overpressurized SIC (30 psig or more pressure) is found, a sample of the SIC pressurizing gas must be taken and analyzed for hydrogen content. If the pressurizing gas in the SIC contains one percent or more hydrogen, the cable must be replaced and a sample of the pressurizing gas in the ECA must be analyzed for hydrogen content. If the pressurizing gas in the ECA contains one percent or more hydrogen, the ECA must be replaced.

WARNING

Spark Igniter Cable Pressurization Tool Kit 9025425 must be operated by authorized personnel trained in the use of the equipment.

a. Obtain the following equipment, or equivalent:

(1) Pressure adapter 9019530-21, packing MS28778-2, and crowfoot wrench 9019552 from SIC pressurization toolkit 9025425-21 or 9025425-31.

(2) One SIC gas sample bottle RL681000.

b. Remove pressure cap AN929-4S from nipple AN816-4S on gas sample bottle, and connect bottle to a vacuum pump capable of reducing bottle pressure to 50 millimeters (2 inches) of mercury or less.

ai. Turn core depressor on adapter 0019530-21 fully counterclockwise, and remove adapter from pressurizing valve by backing off adapter swivel nut A.

aj. Install valve cap on igniter cable pressurizing valve. Torque to 20-25 in-lb, and safetywire.

ak. Disconnect GN_2 supply from pressurizing manifold, and remove manifold from engine.

al. Replace all used packings on test equipment with new packings, and return test equipment to pressurization toolkit.

3.3.7 SAMPLING PRESSURIZING GAS IN SPARK IGNITER CABLES AND ELECTRICAL CONTROL ASSEMBLY. When measuring pressure in spark igniter cables (SIC), if an overpressurized SIC (30 psig or more pressure) is found, a sample of the SIC pressurizing gas must be taken and analyzed for hydrogen content. If the pressurizing gas in the SIC contains one percent or more hydrogen, the cable must be replaced and a sample of the pressurizing gas in the ECA must be analyzed for hydrogen content. If the pressurizing gas in the ECA contains one percent or more hydrogen, the ECA must be replaced.

a. Obtain the following equipment or equivalent:

(1) Pressure adapter 0019530-21, packing MS28778-2, and crowfoot wrench 0019552 from SIC pressurization toolkit 0025425-21.

(2) One SIC gas sample bottle RL081000.

b. Remove pressure cap AN929-4S from nipple AN816-4S on gas sample bottle, and connect bottle to a vacuum pump capable of reducing bottle pressure to 50 millimeters (2 inches) of mercury or less.

c. Open needle valve on gas sample bottle and reduce pressure in bottle to 50 millimeters (2 inches) of mercury or less.

d. Close needle valve on gas sample bottle to lock vacuum in bottle.

e. Remove gas sample bottle from vacuum pump, and install pressure cap AN929-4S on nipple AN816-4S. Torque cap to 55-80 in-lb.

f. Make sure both needle valves on SIC gas sample bottle are closed; then remove cap AN929-2S.

g. Using packing MS28778-2, install pressure adapter 9019530-21 on SIC gas sample bottle nipple AN816-2S. Torque fitting to 25-35 in-lb.

h. Remove cap from overpressurized SIC or ECA pressurizing valve.

NOTE

Contact of the adapter seal with the pressurizing valve stem can be felt by supporting the bottle and adapter and turning adapter swivel nut A by hand.

i. Supporting weight of SIC gas sample bottle and pressure manifold adapter, connect adapter to SIC or ECA pressurizing valve. Tighten adapter swivel nut A (see figure 3-44) 1/2 to one full turn after adapter seal contacts SIC or ECA pressurizing valve stem.

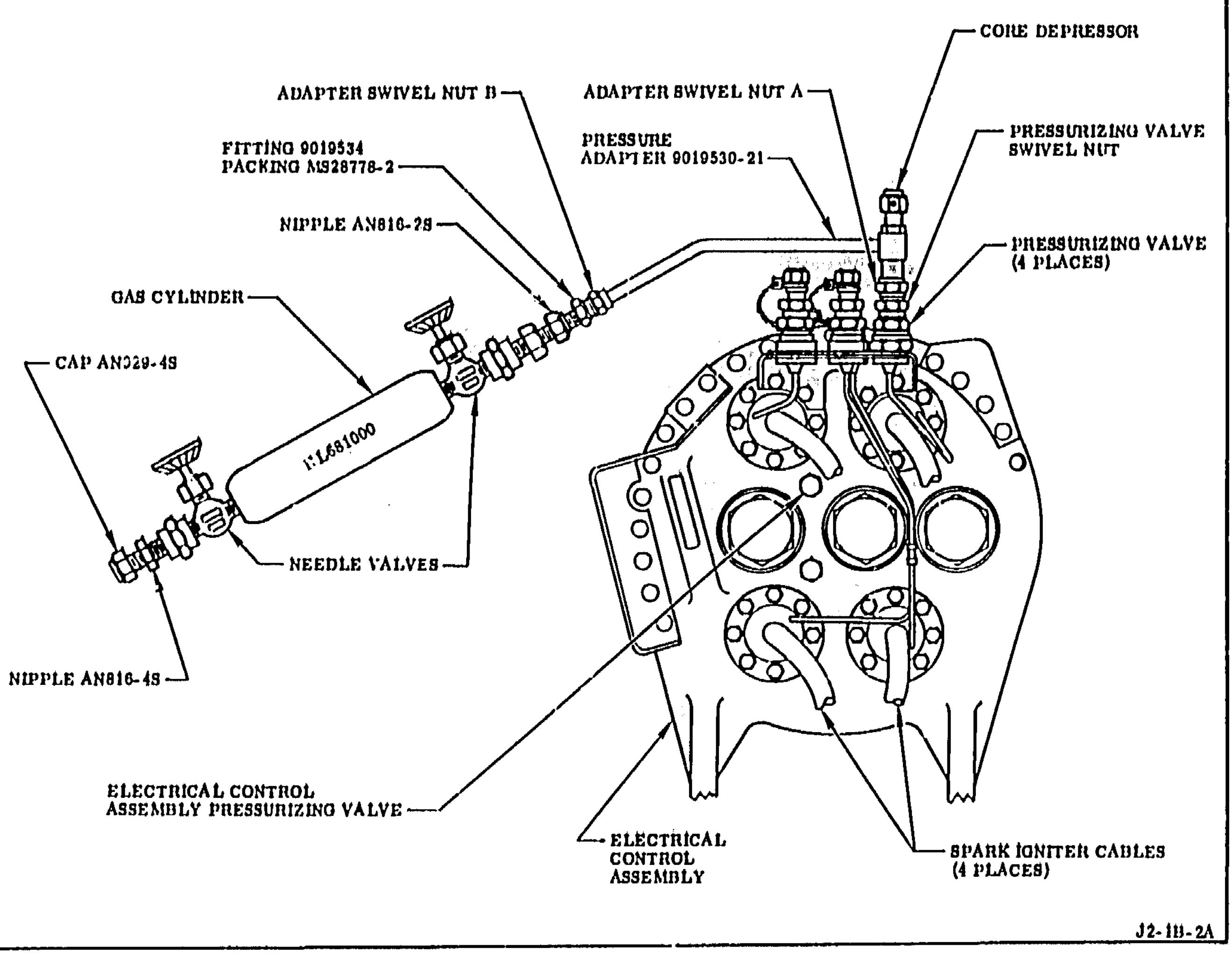


Figure 3-44. Sampling Pressurizing Gas in Spark Igniter Cables and Electrical Control Assembly

CAUTION

Overtorquing the core depressor can damage the valve core and/or depressor.

j. Depress valve core by hand-turning core depressor on adapter clockwise until depressor bottoms (indicated by increased torque required to turn depressor). Do not overtorque depressor.

k. Using crowfoot wrench 9019552, back off SIC or ECA pressurizing valve swivel nut 1-2 full turns while holding valve to prevent it from loosening.

l. If SIC gas sample bottle needle valves must be repositioned for ease of access, loosen pressure adapter swivel nut B and rotate gas sample bottle to desired position. Torque adapter swivel nut B to 25-35 in-lb.

m. Open needle valve on gas sample bottle to allow SIC or ECA pressurizing gas to enter gas sample bottle.

n. Close needle valve on gas sample bottle.

o. Using crowfoot wrench 9019552, close SIC or ECA pressurizing valve by torquing valve swivel nut to 100 ±5 in-lb.

p. Turn core depressor on adapter 9019530-21 counterclockwise and disconnect adapter from SIC or ECA pressurizing valve by backing off adapter swivel nut A.

q. Remove pressure adapter 9019530-21 and packing MS28778-2 from nipple AN816-2S on gas sample bottle.

r. Install cap AN929-2S on gas sample bottle nipple AN816-2S. Torque cap to 25-35 in-lb.

NOTE

If capability for analyzing the gas sample for hydrogen content is not available at the site, the gas sample must be returned to the Engine Contractor, Logistics Program Support, for analysis.

s. Analyze SIC or ECA pressurizing gas for hydrogen content and proceed as follows:

(1) If SIC or ECA gas sample does not contain one percent or more hydrogen, vent or pressurize SIC to required pressure (paragraph 3.3.6.2). Vent or pressurize ECA to required pressure (paragraph 3.3.5.2).

(2) If SIC or ECA gas sample does contain one percent or more hydrogen, replace SIC or ECA. (Refer to R-3825-3.)

3.3.8 FUNCTION-TESTING FLIGHT INSTRUMENTATION PRESSURE TRANSDUCERS. For FI system function test, refer to applicable Stage Contractor document. Use voltage limits specified in this paragraph as acceptance criteria for pressure transducers. The following procedure can be used as an aid in transducer troubleshooting.

NOTE

Transducers not connected to the stage measurement system need not be checked out.

a. Make sure all electrical power to engine is off and all pressure transducers are vented to atmospheric pressure.

b. Disconnect electrical connectors P105, P106, and P107 (primary), and P153, P154, and P155 (auxiliary) at engine customer connect as applicable for troubleshooting. (Refer to R-3825-3.)

c. Apply 28 vdc, 5 amperes, ripple less than 0.1 volt peak, transients less than 50 volts peak with 10-microsecond width and no more than 20 pulses per second to one +28 vdc power supply pin to FI package containing transducer to be tested.

d. Measure and record transducer output between P153-D (-5 vdc return) on auxiliary

package or P105-D (-5 vdc return) on primary package and applicable signal output pin (+0 to 5 vdc output) as tabulated in paragraphs 3.3.8.1 and 3.3.8.2.

e. Apply 28 vdc, ripple less than 0.1 volt peak, transients less than 50 volt peak with 10-microsecond width and no more than 20 pulses per second to 20-percent calibrate input pin. (Use same power supply as used to supply power to package). Repeat step d.

f. Remove voltage applied to 20-percent calibrate input pin.

g. Apply 28 vdc to 80-percent calibrate in put pin. (Use same power supply as used to supply power to package). Repeat step d.

h. Remove voltage applied to 80-percent calibrate input pin.

i. Remove voltage applied to +28 vdc power supply pin.

j. Check initial (ambient), 20-percent calibrate, and 80-percent calibrate readouts. Readouts must be within voltage limits specified in figure 1-6.

k. Refer to Engine Log Book and calculate difference in voltage (Δ E) between initial (ambient) and 20-percent calibrate readouts recorded during engine final acceptance checkout (form DD250 signoff) for oxidizer pump primary seal cavity parameter (PO6) and oxidizer turbine outlet parameter (TG4). For all other pressure parameters calculate difference in voltage (Δ E) between 20-percent calibrate and 80-percent calibrate readouts.

NOTE

If transducer has been replaced in the field, use new values recorded in Engine Log Book during first calibration test after transducer replacement.

l. For oxidizer pump primary/seal cavity parameter (PO6) and oxidizer turbine outlet parameter (TG4), calculate difference in voltage (Δ E) between initial readout (step d) and 20-percent calibrate readout (step e). The voltage difference (Δ E) must be within ±0.100 vdc of the corresponding Δ E calculated in step k from the initial and 20-percent calibrate readouts. For all other pressure parameters, calculate difference in voltage (Δ E) between 20-percent calibrate readout (step e) and 80-percent calibrate readout obtained in step g. The voltage difference (Δ E) valve must be within ±0.100 vdc (±2 percent of 5 vdc full scale) of the corresponding Δ E calculated in step k from the 20-percent and 80-percent calibrate readouts.

m. Example of voltage difference (Δ E) calculation (step l):

	Voltage Readouts (vdc)		
	20 %	80 %	Calculated Δ E
(1) Readouts recorded in Engine Log Book	1.495	4.494	2.999
(2) Readouts obtained during this test	1.499	4.500	3.001
(3) Difference between calculated Δ E values in substeps 1 and 2 (must be within ±0.100 vdc)	--	--	0.002

n. Reconnect electrical connectors disconnected in step b. (Refer to R-3825-3.)

3.3.8.1 Auxiliary Flight Instrumentation Package Pressure Transducer Pin Identification.

Fuel pump balance piston cavity pressure (PF6)

P153-A +28 vdc power supply
P153-B -28 vdc power supply
P153-D -5 vdc return
P154-U +28 vdc power supply
P154-c -28 vdc power supply
P154-$\overline{T}$ -5 vdc return
P155-X +28 vdc 20 percent calibrate
P155-Y +28 vdc 80 percent calibrate
P155-W +0 to 5 vdc output

Oxidizer turbine outlet pressure (TG4)

P153-A +28 vdc power supply
P153-B -28 vdc power supply
P153-D -5 vdc return
P154-U +28 vdc power supply
P154-c -28 vdc power supply
P154-$\overline{T}$ -5 vdc return
P155-L +28 vdc 20 percent calibrate
P155-M +28 vdc 80 percent calibrate
P155-K +0 to 5 vdc output

GG fuel injection pressure (GF4)

P153-A +28 vdc power supply
P153-B -28 vdc power supply
P153-D -5 vdc return
P154-U +28 vdc power supply
P154-c -28 vdc power supply
P154-$\overline{J}$ +28 vdc 20 percent calibrate
P154-$\overline{k}$ +28 vdc 80 percent calibrate
P154-$\overline{s}$ +0 to 5 vdc output
P154-$\overline{T}$ -5 vdc return

Heat exchanger oxidizer inlet pressure (HO1)

P153-A +28 vdc power supply
P153-B -28 vdc power supply
P153-D -5 vdc return
P154-U +28 vdc power supply
P154-c -28 vdc power supply
P154-$\overline{d}$ +28 vdc 20 percent calibrate
P154-$\overline{e}$ +28 vdc 80 percent calibrate
P154-$\overline{m}$ +0 to 5 vdc output
P154-$\overline{T}$ -5 vdc return

Engines incorporating MD269, MD282, MD296, MD313, or MD315 change, helium tank pressure (redundant) NN1

P153-A +28 vdc power supply
P153-B -28 vdc power supply
P153-D -5 vdc return
P154-U +28 vdc power supply
P154-c -28 vdc power supply
P154-$\overline{f}$ +28 vdc 20 percent calibrate
P154-$\overline{g}$ +28 vdc 80 percent calibrate
P154-$\overline{n}$ +0 to 5 vdc output
P154-$\overline{T}$ -5 vdc return

PU valve inlet pressure (PO8)

P153-A +28 vdc power supply
P153-B -28 vdc power supply
P153-D -5 vdc return
P154-U +28 vdc power supply
P154-c -28 vdc power supply
P154-$\overline{O}$ +28 vdc 20 percent calibrate
P154-P +28 vdc 80 percent calibrate
P154-V +0 to 5 vdc output
P154-T -5 vdc return

PU valve outlet pressure (PO9)

P153-A +28 vdc power supply
P153-B -28 vdc power supply
P153-D -5 vdc return
P154-U +28 vdc power supply
P154-c -28 vdc power supply
P154-$\overline{X}$ +28 vdc 20 percent calibrate
P154-Y +28 vdc 80 percent calibrate
P154-W +0 to 5 vdc output
P154-T -5 vdc return

GG oxidizer injection pressure (GO5)

P153-A +28 vdc power supply
P153-B -28 vdc power supply
P153-D -5 vdc return
P154-U +28 vdc power supply
P154-c -28 vdc power supply
P154-$\overline{Z}$ +28 vdc 20 percent calibrate
P154-a +28 vdc 80 percent calibrate
P154-$\overline{h}$ +0 to 5 vdc output
P154-$\overline{T}$ -5 vdc return

Oxidizer turbopump primary seal cavity pressure (PO6)
- P153-A +28 vdc power supply
- P153-B -28 vdc power supply
- P153-D -5 vdc return
- P154-U +28 vdc power supply
- P154-c -28 vdc power supply
- P154-$\overline{w}$ +28 vdc 20 percent calibrate
- P154-$\overline{x}$ +28 vdc 80 percent calibrate
- P154-$\overline{v}$ +0 to 5 vdc output
- P154-$\overline{T}$ -5 vdc return

Engines not incorporating MD269, MD282, MD296, MD313, or MD315 change, oxidizer turbopump bearing coolant pressure (PO7)

Engines incorporating MD269, MD282, MD296, MD313, or MD315 change, start tank pressure (redundant) (TF1)
- P153-A +28 vdc power supply
- P153-B -28 vdc power supply
- P153-D -5 vdc return
- P154-U +28 vdc power supply
- P154-c -28 vdc power supply
- P154-$\overline{t}$ +28 vdc 20 percent calibrate
- P154-$\overline{u}$ +28 vdc 80 percent calibrate
- P154-$\overline{y}$ +0 to 5 vdc output
- P154-$\overline{T}$ -5 vdc return

Oxidizer turbine inlet pressure (TG3)
- P153-A +28 vdc power supply
- P153-B -28 vdc power supply
- P153-D -5 vdc return
- P154-U +28 vdc power supply
- P154-c -28 vdc power supply
- P154-$\overline{T}$ -5 vdc return
- P155-F +28 vdc 20 percent calibrate
- P155-G +28 vdc 80 percent calibrate
- P155-E +0 to 5 vdc output

Engine regulator outlet pressure (NN2)
- P153-A +28 vdc power supply
- P153-B -28 vdc power supply
- P153-D -5 vdc return
- P154-U +28 vdc power supply
- P154-c -28 vdc power supply
- P154-$\overline{T}$ -5 vdc return
- P155-S +28 vdc 20 percent calibrate
- P155-T +28 vdc 80 percent calibrate
- P155-R +0 to 5 vdc output

Main oxidizer injection pressure (CO3)
- P153-A +28 vdc power supply
- P153-B -28 vdc power supply
- P153-D -5 vdc return
- P154-U +28 vdc power supply
- P154-c -28 vdc power supply
- P154-$\overline{T}$ -5 vdc return
- P155-U +28 vdc 20 percent calibrate
- P155-V +28 vdc 80 percent calibrate
- P155-Q +0 to 5 vdc output

Main fuel injection pressure (CF2)
- P153-A +28 vdc power supply
- P153-B +28 vdc power supply
- P153-D -5 vdc return
- P154-U +28 vdc power supply
- P154-c -28 vdc power supply
- P154-$\overline{T}$ -5 vdc return
- P155-N +28 vdc 20 percent calibrate
- P155-P +28 vdc 80 percent calibrate
- P155-H +0 to 5 vdc output

3.3.8.2 Primary Flight Instrumentation Package Pressure Transducer Pin Identification.

Helium tank pressure (NN1)
- P105-A +28 vdc power supply
- P105-B -28 vdc power supply
- P105-D -5 vdc return
- P106-M +28 vdc power supply
- P106-N -28 vdc power supply (redundant)
  (It is not necessary to connect both sets of power supply pins to perform this procedure.)
- P106-U +28 vdc 20 percent calibrate
- P106-V +28 vdc 80 percent calibrate
- P106-T +0 to 5 output
- P106-Z -5 vdc return (redundant)

Start tank pressure (TF1)
- P105-A +28 vdc power supply
- P105-B -28 vdc power supply
- P105-D -5 vdc return
- P106-M +28 vdc power supply
- P106-N -28 vdc power supply
- P106-c +28 vdc 20 percent calibrate
- P106-$\overline{d}$ +28 vdc 80 percent calibrate
- P106-$\overline{b}$ +0 to 5 vdc output
- P106-$\overline{Z}$ -5 vdc return

Fuel turbopump discharge pressure (PF3)
- P105-A +28 vdc power supply
- P105-B -28 vdc power supply
- P105-D -5 vdc return
- P106-M +28 vdc power supply
- P106-N -28 vdc power supply
- P106-W +28 vdc 20 percent calibrate
- P106-X +28 vdc 80 percent calibrate
- P106-f +0 to 5 vdc output
- P106-$\overline{Z}$ -5 vdc return

Oxidizer pump discharge pressure (PO3)
- P105-A +28 vdc power supply
- P105-B -28 vdc power supply
- P105-D -5 vdc return
- P106-M +28 vdc power supply
- P106-N -28 vdc power supply
- P106-k +28 vdc 20 percent calibrate
- P106-m +28 vdc 80 percent calibrate
- P106-o +0 to 5 vdc output
- P106-$\overline{Z}$ -5 vdc return

Thrust chamber pressure (CG1)
- P105-A +28 vdc power supply
- P105-B -28 vdc power supply
- P105-D -5 vdc return
- P106-M +28 vdc power supply
- P106-N -28 vdc power supply
- P106-g +28 vdc 20 percent calibrate
- P106-n +28 vdc 80 percent calibrate
- P106-p +0 to 5 vdc output
- P106-$\overline{Z}$ -5 vdc return

Engines not incorporating MD237 change, GG chamber pressure (GG1)

Engines incorporating MD237 change, fuel turbine pressure (TG1)
- P105-A +28 vdc power supply
- P105-B -28 vdc power supply
- P105-D -5 vdc return
- P106-M +28 vdc power supply
- P106-N -28 vdc power supply
- P106-j +28 vdc 20 percent calibrate
- P106-r +28 vdc 80 percent calibrate
- P106-h +0 to 5 vdc output
- P106-$\overline{Z}$ -5 vdc return

Engines not incorporating MD233, or MD304 change, fuel turbopump interstage pressure (PF6)

Engines incorporating MD304 change, low-range thrust chamber pressure
- P105-A +28 vdc power supply
- P105-B -28 vdc power supply
- P105-D -5 vdc return
- P106-M +28 vdc power supply
- P106-N -28 vdc power supply
- P106-E +28 vdc 20 percent calibrate
- P106-F +28 vdc 80 percent calibrate
- P106-J +0 to 5 vdc output
- P106-Z -5 vdc return

3.3.9 RESISTANCE-TESTING FLIGHT INSTRUMENTATION TEMPERATURE TRANSDUCERS. For FI system function test, refer to applicable Stage Contractor document. The following resistance test procedure can be used as an aid in transducer troubleshooting. Using an approved resistance tester, measure resistance of each temperature transducer at customer connect. Transducer temperature must be between 38° and 110° F. Maximum current used through resistance element and resistance must be within the limits listed in figure 3-45.

Temperature Transducers	Maximum Current of Measuring Device (Amps)	Pin to Pin	Resistance (Ohms)
		P108	
Fuel injection	0.0047	t to y t to w	1,370 ±100
Thrust chamber jacket No. 1	0.0047	u to p u to n	1,370 ±100
Thrust chamber jacket No. 2	0.0047	s to x s to v	1,370 ±100
Oxidizer turbine outlet	0.0015	m to g m to f	55 ±5
Oxidizer turbine inlet	0.0015	r to j r to h	55 ±5

Figure 3-45. Temperature Transducer Resistance Limits (Sheet 1 of 3)

Temperature Transducers	Maximum Current of Measuring Device (Amps)	Pin to Pin	Resistance (Ohms)
		P108 (cont)	
Fuel turbine inlet	0.0015	k to d k to c	55 ±5
Start tank gas	0.00083	G to J G to I H to L H to K	1,370 ±100
Helium tank gas	0.00083	M to U M to T	1,370 ±100
Oxidizer turbopump discharge	0.0007	b to X b to W	1,370 ±100
	0.00058	S to O S to N	
Fuel turbopump discharge	0.0047	e to a e to Z V to R V to P	1,370 ±100
		P54	
ECA No. 1	0.0015	p to u p to v	218 ±17
ECA No. 2	0.0015	B to F B to G	218 ±17
		P164	
Auxiliary FI package	0.0015	r to q r to p	218 ±17
		P106	
Primary FI package	0.0015	K to S K to n	218 ±17
		P166	
Heat exchanger oxidizer outlet No. 2 (engines incorporating MD100 change)	0.0009	X to G X to F	405 ±33
Heat exchanger oxidizer outlet No. 1 (engines incorporating MD100 change)	0.0009	Y to J Y to H	405 ±33
Fuel bleed valve	0.0047	Z to L Z to K M to b M to n	1,370 ±100
Oxidizer bleed valve ("A" sensor) (engines not incorporating MD248 change)	0.0007	V to f V to e	1,370 ±100
Oxidizer bleed valve ("B" sensor)	0.0007	W to E W to D	1,370 ±100
Oxidizer turbopump bearing coolant	0.0007	g to h g to j	1,370 ±100

Figure 3-45. Temperature Transducer Resistance Limits (Sheet 2 of 3)

Temperature Transducers	Maximum Current of Measuring Device (Amps)	Pin to Pin	Resistance (Ohms)
		P156 (cont)	
Fuel turbopump bearing (engines not incorporating MD172 or MD248 change) (MD172 change removes the instrumentation port.)	0.0047	$\underline{c}$ to P $\underline{\bar{c}}$ to N	1,370 ±100
MOV closing control line (SII-stage engines incorporating MD248 change)	0.0021	V to $\underline{e}$ V to $\underline{\bar{I}}$	109 ±9
MOV housing (SII-stage engines incorporating MD248 change)	0.0021	$\underline{c}$ to P $\underline{\bar{c}}$ to N	109 ±9

Figure 3-45. Temperature Transducer Resistance Limits (Sheet 3 of 3)

3.3.10 RESISTANCE-TESTING IGNITION DETECTOR PROBE.

a. Cut lockwire and disconnect electrical connector from probe.

CAUTION

The applied voltage must not be greater than 5 vdc during substeps 1, 2, and 3.

b. Using resistance-measuring device that is accurate within one percent and capable of measuring resistances of 0.1, 100, 200, and greater than 100,000 ohms, perform the following resistance test on probe: (Reject probe if it does not meet requirements of resistance test.)

Operation	Result
(1) Pin A to pin B.	Resistance is 100±2.5 ohms.
(2) Pin B to pin C.	Resistance is 100±2.5 ohms.
(3) Pin A to pin C.	Resistance is 200±5 ohms.
(4) Pin B to pin D.	Resistance is greater than 100,000 ohms.
(5) Pin B to probe electrical receptacle case.	Resistance is greater than 100,000 ohms.
(6) Pin D to probe electrical receptacle case.	Resistance is greater than 100,000 ohms.
(7) Pin F to probe electrical receptacle case.	Resistance is less than 0.1 ohm.
(8) Pin D to pin E.	Resistance is less than 0.1 ohm.

c. Using new gasket, connect electrical connector P10 to ignition detector probe. Torque connector to 40-50 in-lb, and safetywire.

d. Turn on engine control power.	Ignition-complete signal from engine control system must not come on.

e. Turn off engine control power.

3.3.11 TESTING SPEED AND FLOW TRANSDUCERS. The following resistance test should be used for post-installation testing and as an aid in transducer troubleshooting.

a. Connect test lead of resistance measuring device (Triplett 630 multimeter or Simpson 260 multimeter) to engine ground strap located at fuel inlet duct flange.

Operation	Result
b. Set multimeter on highest ohms range and measure resistance between each pin of transducer being tested and engine ground strap. Allow 30 seconds for capacitor charging; then take reading.	Resistance must be greater than 5 megohms.

c. Disconnect multimeter test leads.

Operation	Result
d. Measure resistance between pins B and C of transducer being tested.	Resistance must be greater than 500,000 ohms.

e. Measure transducer resistance as specified in figure 3-45A.

Connector P100 Pins	Transducer Pins	Function	Resistance Ohms @ 70°±20° F
A - B	C - D	Fuel Pump Speed, Secondary Coil	300 ±60
C - D	A - B	Fuel Pump Speed, Primary Coil	250 ±50
E - F	C - D	Oxidizer Pump Speed, Secondary Coil	300 ±60
G - H	A - B	Oxidizer Pump Speed, Primary Coil	250 ±50
J - K	C - D	Fuel Flow, Secondary Coil	1,270 ±500
N - P	A - B	Fuel Flow, Primary Coil	1,270 ±500
R - S	C - D	Oxidizer Flow, Secondary Coil	1,270 ±500
T - U	A - B	Oxidizer Flow, Primary Coil	1,270 ±500
-----	C - D	Fuel Flow (Redundant), Secondary Coil[a]	1,270 ±500
-----	A - B	Fuel Flow (Redundant), Primary Coil[a]	1,270 ±500
-----	C - D	Oxidizer Flow (Redundant), Secondary Coil[b]	1,270 ±500
-----	A - B	Oxidizer Flow (Redundant) Primary Coil[b]	1,270 ±500

(a) On engines not incorporating MD150, MD280 or MD281 change, redundant fuel flowrate transducer designated J110A.
(b) On engines not incorporating MD150, MD280 or MD281 change, redundant oxidizer flowrate transducer designated J111A.

Figure 3-45A. Speed and Flow Transducer Resistance Limits

3.3.12 FUNCTION-TESTING PROPELLANT UTILIZATION VALVE (ENGINES NOT INCORPORATING MD366 OR MD371 CHANGE). The following procedure may be used to test the PU valve using the stage PU automatic checkout system, or as an aid in troubleshooting. (Refer to section II for PU valve electrical requirements.)

a. Energize valve servomotor fixed-phase winding with 115 ±3 volts rms, 400 ±25 Hz through connector P38, pins R and P.

NOTE

Voltage ratios are used to determine potentiometer position.

$$\text{Voltage ratio} = \frac{\text{potentiometer output volts}}{\text{potentiometer input volts}}$$

- When determining clockwise and counterclockwise rotation of the valve, the viewer must assume he is looking up the center of the valve outlet toward the end of the valve actuator shaft.

Operation	Result
b. Apply 40 ±1 volts rms, 400 ±25 Hz, to control-phase winding through connector P38, pins C and E, so that fixed-phase leads control phase by 90 ±15 degrees.	PU valve closes.
c. Apply 5.00 ±0.50 vdc through connector P107, pin E, to telemetry position potentiometer. Position potentiometer output at connector P107, pin c.	With valve closed (fully counterclockwise), telemetry position potentiometer must have a voltage ratio of 0.002 to 0.1.

d. Remove power from fixed-phase and control-phase windings.

Operation	Result
e. Apply 115 ±3 volts rms, 400 ±25 Hz, through connector P38, pins R and P, to fixed-phase winding, and apply 40 ±1 volts rms, 400 ±25 Hz, through connector P38, pins C and E, with pin D as null, to control-phase winding so that control-phase leads fixed phase by 90 ±15 degrees.	PU valve opens.
f. Read telemetry position potentiometer output at connector P107, pin c.	With valve open (fully clockwise) telemetry position potentiometer must have a voltage ratio of 0.9 to 1.0.

g. Return valve to null position and remove electrical power.

3.3.12A FUNCTION-TESTING MIXTURE RATIO CONTROL VALVE (ENGINES INCORPORATING MD366 OR MD371 CHANGE). The following procedure may be used to test the MRCV with the engine control in the components test mode using the stage MRCV actuation control system and a continuous, noncommutated (hardwire) system capable of recording the engine helium control valve solenoid event, the MRCV low EMR command event, and the MRCV analog position. (Refer to section II for MRCV electrical power requirements.)

a. Remove protective covers from the following:

(1) Thrust chamber exit (or one-desiccant access cover from exit closure).

(2) Oxidizer turbopump primary seal drain line. (Stage overboard drain line on engines incorporating MD301, MD302, MD322, or MD323 change.)

(3) Oxidizer turbopump intermediate seal purge check-valve vent.

WARNING

Failure to observe safety requirements of step b can result in injury to personnel.

b. Direct all personnel to stand behind adequate safety barriers or at a safe distance from engine while performing this test.

CAUTION

Opening the MOV with the stage oxidizer tanks pressurized and the pre-valve open or with more than 5 psig in the oxidizer inlet duct with the pre-valve closed can damage the engine oxidizer flowmeter by dry-spinning in excess of 60 seconds.

c. Verify that pressure in the oxidizer inlet duct is not greater than 5 psig and that the stage oxidizer pre-valve is closed.

d. Slowly apply pressure of 1,400-3,200 psig to engine helium tank. Maintain a minimum pressure of 800 psig during test.

e. Read potentiometer output at connector P107, pin c.

f. Energize low EMR command.

NOTE

To obtain valid readings, allow a minimum of 2 seconds between operations g, i, k, and m.

Operation	Result
g. Energize engine helium and mainstage control valves.	MRCV must move to low EMR (MRCV open).

NOTE

The mainstage control valve is energized to prevent excessive loss of helium through engine purges.

Operation	Result
h. Read potentiometer output at connector P107, pin c.	On engines incorporating MD371 change, voltage change from step e must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step e must be between 0.6 and 1.0 vdc.
i. Deenergize low EMR command.	MRCV must move to high EMR (MRCV closed).

j. Read potentiometer output at connector P107, pin c.

Operation	Result
k. Energize low EMR command.	MRCV must move to low EMR (MRCV open).
l. Read potentiometer output at connector P107, pin c.	On engines incorporating MD371 change, voltage change from step j must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step j must be between 0.6 and 1.0 vdc.
m. Deenergize engine mainstage and helium control valves.	MRCV must move to high EMR (MRCV closed).

n. Approximately 5 seconds after deenergizing helium control valve, deenergize low EMR command.

Operation	Result
o. Determine MRCV operating times.	MRCV operating times must be within limits of figure 1-11.

p. Decrease pressure to helium tank to zero.

q. Energize helium control valve and allow all pressure to vent from helium tank; then deenergize helium control valve.

r. Reinstall protective covers removed in step a.

3.3.13 RESISTANCE-TESTING ENGINE SOLENOID CONTROL VALVES.

a. Determine that power has not been applied to solenoid coils within 4 hours before performing following resistance tests.

b. Obtain the following equipment:

(1) Wheatstone bridge or digital ohmmeter (accuracy within ±0.1 ohm).

(2) Resistance test selector box 99-9019902.

(3) Special interconnect cables (MRCV and start tank emergency vent solenoid-to-selector box). Obtain special cables from Rocketdyne.

(4) Strap-on thermometer (accuracy within ±2.0° F).

(5) Insulation resistance tester, 500 vdc (accuracy within ±10% and current limited to 10 ma. maximum at 500 vdc).

c. Depressurize all engine systems and shut off all electrical power to engine.

d. Place a strap-on thermometer on mainstage or ignition-phase solenoid case. Allow thermometer to stabilize. Location selected for temperature measurement will be considered engine hardware temperature and will be used for all control valves.

e. Perform the following resistance test on each interconnect test cable before and in sequence with applicable solenoid resistance test.

(1) Connect applicable interconnect test cable (determined by solenoid(s) to be tested) to selector box.

(2) Connect a grounding cable between selector box GND jack and test cable connector shell.

(3) Connect a 500 vdc insulation resistance tester to MEGOHMS jacks on selector box.

Operation	Result
(4) For all solenoid interconnect cables, turn selector box knob to A & B TO GND. Momentarily apply 500 vdc, and check insulation resistance.	Resistance must be 500 megohms minimum.
(5) For all solenoid interconnect cables except start tank emergency vent valve cable and MRCV cable, turn selector box knob to C TO GND. Momentarily apply 500 vdc, and check insulation resistance.	Resistance must be 500 megohms minimum.
(6) For all solenoid interconnect cables except start tank emergency vent valve cable and MRCV cable, turn selector box knob to A & B TO C. Momentarily apply 500 vdc, and check insulation resistance.	Resistance must be 500 megohms minimum.

(7) Turn selector knob to OFF.

(8) Disconnect ground cable from interconnect test cable connector shell.

f. Connect ground cable to engine grounding strap at fuel inlet duct.

g. Connect Wheatstone bridge or digital ohmmeter to OHMS jacks on resistance test selector box.

h. Perform the following test independently on each of the 7 engine solenoids (ignition-phase, mainstage, start tank discharge, helium control, helium tank emergency vent, start tank emergency vent, and MRCV).

(1) Disconnect applicable electrical connector P14, P15, P18, P13, P17, P55, or P30A. (Refer to R-3825-3.)

(2) Using one of the following test cables as applicable, connect cable to solenoid J-connector.

(a) For electrical connectors J13, J14, J15, J17, and J18 use cable 9019946 (alternate EWR1114834).

(b) For electrical connector J55 use cable 9019946-11 (alternate EWR131276-11).

(c) For electrical connector J30A use cable 9019946-21 (altern... EWR131276-21).

(3) Record reading on strap-on thermocouple.

Operation	Result
(4) For all solenoids, turn selector knob to A TO B.	Ohms resistance must be within limit band shown in figures 1-8A, 1-8B, and 1-8C for measured hardware temperature.
(5) For all solenoids, turn selector knob to A & B TO GND. Momentarily apply 500 vdc, and check insulation resistance.	Resistance must be 50 megohms minimum.
(6) For all solenoids, except start tank emergency vent (J55) and MRCV (J36A), turn selector knob to C TO GND. Momentarily apply 500 vdc, and check insulation resistance.	Resistance must be 50 megohms minimum.
(7) For all solenoids, except start tank emergency vent (J55) and MRCV (J36A), turn selector knob to A & B TO C. Momentarily apply 500 vdc, and check insulation resistance.	Resistance must be 50 megohms minimum.

(8) Turn selector knob to OFF.

(9) Disconnect test cable from solenoid connector, and reconnect engine electrical harness to its solenoid connector. (Refer to R-3825-3.)

3.3.14 RESISTANCE-TO-GROUND-TESTING ENGINE ELECTRICAL SYSTEM.

a. Disconnect interface electrical connectors P51 and P54. (Refer to R-3825-3.)

b. Install resistance test adapter kit 9025591 on connector P51.

c. Connect test leads of resistance measuring device (Triplett 630 multimeter or Simpson 260 multimeter) to conductor on back of test receptacle (installed in step b) and to engine ground strap located at fuel inlet duct flange.

Operation	Result
d. Set multimeter on highest ohms range and measure resistance between test receptacle and engine ground strap. Allow 30 seconds for capacitor charging; then take reading.	Resistance must be greater than 5 megohms.

e. Disconnect multimeter test leads.

f. Remove test receptacle from connector P51.

g. Reconnect interface electrical connectors P51 and P54. (Refer to R-3825-3.)

3.3.15 LEAK-TESTING START SYSTEM. Refer to section II for engine checkout constraints before performing this test. Refer to paragraph 3.3.2 for seal leak-test ports.

a. Remove thrust chamber exit closure.

NOTE

Exhaust system test plates must be installed in order to leak-test the STDV seat.

b. Install exhaust system test plates (paragraph 3.3.3.).

NOTE

The thrust chamber throat plug must be installed to leak-test the start tank refill check valves.

c. Install Presstite tape, Type 587.3 (Interchemical Corp), and cover with 2-inch-wide Teflon Temp-R-Tape, Type C (Connecticut Hard Rubber Co), in thrust chamber throat plug seating area as follows:

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

(1) Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe a 4-inch portion of thrust chamber throat approximately 9 inches down from injector face or approximately 4 inches from throat.

(2) Cut two 28 ±1 inch pieces of 1/2-inch-wide Presstite tape.

(3) Cover Presstite tape with Teflon Temp-R-Tape. Press tape slightly to make sure tape sticks to Presstite tape.

(4) Remove paper backing from the 2 strips of tape, and install tape around inside of thrust chamber throat approximately 11 inches from face of injector or approximately 6 inches from throat. Trim ends, as necessary, to make one continuous band of tape. Make sure tape ends are pressed firmly together. Press tape slightly with fingers, as required, to make tape stay in place.

(5) Cut a 4-inch piece of Presstite tape. Place tape on workbench with paper backing facing workbench. Cut tape into 2 pieces 1/4 inch wide by 4 inches in length.

(6) Place throat plug half that contains burst diaphragm on workbench with flat up. Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe flat.

(7) Install the two 4-inch pieces of tape on flat of throat plug. Stretch each piece to width of flat, and install on each side of hole to form 2 seals on flat. Cover each piece of Presstite tape with Teflon Temp-R-Tape. Press tape slightly with fingers, as required, to make tape stay in place. Trim ends of tape at each end flush with edge of flat.

NOTE

Thrust Chamber Throat Plug Kit G3120MD3 must be installed dry (no lubricant).

d. Place hand screw in throat plug in stowed position to prevent movement during plug installation.

e. Install half of throat plug into thrust chamber combustion area with handle-equipped end facing thrust chamber exit. Make sure throat plug half does not disturb tape.

f. Install other half of throat plug, and mate halves of plug. Make sure tape strips on flat stay in place during plug installation.

g. Grasp handles, and pull sections together toward throat area until a tight fit is obtained.

h. Isolate stage fuel tank pressurization system from engine HYDROGEN TANK PRESSURIZATION customer connect (not applicable on SII-stage center engine).

i. Remove plug from monitor port on thrust chamber throat plug.

j. Connect a regulated supply of helium (refer to section II) capable of supplying 500 ±20 psig to START TANK INITIAL FILL customer connect.

k. Remove protective closure from start tank vent-and-relief valve drain.

l. Remove threaded plugs from leak detection ports as required for system test. (See figure 3-32.)

m. Apply 500 ±20 psig to START TANK INITIAL FILL customer connect.

Operation	Result
n. Leak-test the following areas of the start system:	Leakage is not allowable.

(1) Start tank support-and-fill valve to start tank (F2).

(2) Start tank vent-and-relief valve to start tank (F3).

(3) STDV to start tank (F5).

(4) Start tank pressure instrumentation line TF1 (F1) from start tank to primary F1 package (on engines incorporating MD269, MD282, MD296, MD313, or MD315 change, line to auxiliary FI package).

(5) On engines not incorporating MD150, MD280, or MD281 change, line from tee in line TF1 (near primary package) to stage static-test transducer.

(6) On engines incorporating MD331 or MD344 change but not incorporating MD254 or MD347 change, start tank liquid refill line from tee in instrumentation line TF1 (near start tank support-and-fill valve) to start tank liquid refill check valve.

(7) On engines not incorporating MD331 or MD344 change or on engines incorporating MD347 change, start tank liquid refill line from tee in instrumentation line TF1 (near start tank support-and-fill valve) to plugged end of refill line.

(8) Start tank temperature transducer (F4) (near STDV attach flange).

(9) On engines not incorporating MD320 change, start tank pressure switch blank (F52).

(10) On engines incorporating MD320 change, start tank emergency vent valve to start tank support-and-fill valve (F52).

Operation	Result
o. Using helium leak detector, leak-test braided sections of START TANK INITIAL FILL customer-connect line.	Leakage is not allowable.
p. Using pneumatic flowtester, measure leakage at start tank vent- and relief-valve drain line. Record as start tank vent- and relief-valve seat leakage.	Maximum allowable leakage is 2 scim.
q. Using pneumatic flowtester, measure leakage at STDV drain line port on engines not incorporating MD334 change or at fuel turbine drain line exit on engines incorporating MD234 change. Record as STDV seat leakage.	Maximum allowable leakage is 5 scim.
r. Using pneumatic flowtester, measure leakage at thrust chamber throat plug monitor port. (This is the combined leakage of the start tank gaseous and liquid refill check valves.) If leakage exceeds 5 scim, perform steps s through v. If leakage is 5 scim or less, proceed to step w.	Maximum allowable leakage is 5 scim.

s. Disconnect start tank liquid refill line from ASI lower fuel line.

Operation	Result
t. Using pneumatic flowtester, measure leakage at refill line flange. Record as start tank liquid-refill check valve reverse leakage.	Maximum allowable leakage is 5 scim.
u. Subtract leakage measured in step r. Record as start tank gaseous-refill check valve reverse leakage.	Maximum allowable leakage is 5 scim.

v. Install new seal and connect start tank liquid-refill line to ASI lower fuel line. Torque bolts to 52-58 in-lb and safetywire. (Flange connection must be leak tested during thrust chamber leak test.)

w. Decrease pneumatic pressure to START TANK INITIAL FILL customer connect to zero.

x. Disconnect regulated pneumatic system from START TANK INITIAL FILL customer connect.

Operation	Result
y. Using pneumatic flowtester, measure leakage at start tank initial fill line. Record as start tank initial-fill check valve reverse leakage.	Maximum allowable leakage is 2 scim.

Operation	Result
z. Apply 550 psia maximum to START TANK VENT VALVE CONTROL customer connect.	Start tank pressure vents.
aa. Leak-test start tank vent valve control line.	Leakage is not allowable.
ab. Decrease pneumatic pressure to start tank vent valve control to zero.	Start tank vent valve closes.

ac. Return stage fuel tank pressurization system to pre-test configuration. (Reconnect stage fuel tank pressurization line.)

ad. Remove exhaust system test plates (paragraph 3.3.4).

NOTE

The burst diaphragm is removed to prevent accidental pressurization of the thrust chamber.

ae. If throat plug is to remain installed for subsequent thrust chamber repressurizing, remove burst diaphragm from throat plug until repressurization is required. (When reinstalling burst diaphragm, torque to 135-165 in-lb.) If throat plug is to be removed, proceed as follows:

(1) Move hand screw on throat plug from stowed position to operating position, and rotate hand screw until one half of throat plug slides forward. Place hand screw in stowed position.

(2) Push throat plug into combustion area.

(3) Rotate one half of throat plug and disengage from pivot.

(4) Remove throat plug sections from thrust chamber.

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

af. Remove tape from thrust chamber throat and throat plug. Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe throat area where tape was installed, to make sure area is clean.

ag. Install thrust chamber exit closure. (Tighten nuts handtight plus 1/4 turn.) If thrust chamber diffuser is installed, secure exit closure with 20 tension springs RD395-44050.

ah. Reinstall threaded plugs in leak detection ports and torque to 22-28 in-lb. (Safetywire plugs after prelaunch leak tests.)

ai. Disconnect test equipment.

aj. Install protective closure on start tank vent-and-relief valve drain.

3.3.16 MASS-LOSS-TESTING START TANK. Refer to section II for engine checkout constraints before performing this test.

a. Connect a regulated supply of helium (refer to section II) capable of supplying a minimum of 500 psig to START TANK INITIAL FILL customer connect.

NOTE

The monitoring system should contain a digital voltmeter capable of both visual and printout readings. The start tank GG transducer amplifier must have an electrical readout of 0-5 vdc, corresponding to a temperature range of -350° to +100° F.

b. Connect a monitoring system to engine connector P106, pins b, c, d, M, N, R, and Z, and connector P108, pins I, J, G, K, L, and H. Monitoring systems must be capable of monitoring the following parameters:

(1) Start tank pressure (TF1): connector P106, pins b, c, d, M, N, R, and Z.

(2) Start tank gas temperature (TFT1): connector P108, pins I, J, G, K, L, and H.

c. On engines incorporating MD320 change, perform steps d through f. On engines not incorporating MD320 change, proceed to step g.

d. Slowly pressurize start tank to 500 ±20 psig.

e. Shut off pressure to START TANK INITIAL FILL customer connect.

f. Energize start tank emergency vent valve. When start tank pressure has decreased to zero, deenergize start tank emergency vent valve.

g. Slowly pressurize start tank to 500 ±20 psig.

h. Check start tank temperature periodically for a minimum of one hour after initial tank pressurization. Make sure start tank gas temperature has stabilized before proceeding with test.

i. After start tank gas temperature has stabilized, decrease pressure to START TANK INITIAL FILL customer connect to zero. (Check valve isolates pressure in start tank.)

j. Obtain temperature and pressure voltage readings. Record readings and time readings were obtained.

k. Determine mass (M) using the following formula:

$$M = \frac{5.2533\ PV}{TV + 1.222}$$

where

M = mass (pounds)
PV = pressure indication (volts)
TV = temperature indication (volts)

l. Wait exactly one hour from time recorded in step j; then record temperature and pressure readings. Using these readings, repeat step k.

m. Compute helium loss by subtracting final weight (step l) from initial weight (step j). Maximum mass loss allowable is 0.0066 pound.

n. If value obtained in step m is equal to or less than limit specified, start tank mass loss is acceptable. If value is less than -0.001 pound, record mass loss as zero.

o. If value obtained in step m is more than limit specified, repeat steps j through n 3 consecutive times and compute average mass loss for the 4 tests. System is acceptable if average mass loss does not exceed 0.0066 pound.

p. Apply 550 psia maximum pneumatic pressure to START TANK VENT VALVE CONTROL customer connect. Pressure in start tank vents from START TANK VENT & RELIEF VALVE DRAIN customer connect.

Operation	Result
q. Leak-test flanges and connections in start tank vent valve control customer-connect line.	Leakage is not allowable.

r. Decrease pneumatic pressure to START TANK VENT VALVE CONTROL customer connect to zero.

3.3.17 PRESSURE-DECAY-TESTING START TANK. Refer to section II for engine checkout constraints before performing this test.

a. Connect a regulated supply of helium (refer to section II) capable of supplying a minimum of 500 psig to START TANK INITIAL FILL customer connect.

b. Connect a monitoring system to engine connector P106, pins b, c, d, M, N, R, and Z. Monitoring system must be capable of monitoring start tank pressure (TF1).

c. On engines incorporating MD320 change, perform steps d through f. On engines not incorporating MD320 change, proceed to step g.

d. Slowly pressurize start tank to 500 ±20 psig.

e. Shut off pressure to START TANK INITIAL FILL customer connect.

f. Energize start tank emergency vent valve. When start tank pressure has decreased to zero, deenergize start tank emergency vent valve.

g. Slowly pressurize start tank to 500 ±20 psig.

h. After a minimum of one hour following initial start-tank pressurization (start tank stabilization period), decrease pressure to START TANK INITIAL FILL customer connect to zero. (Check valve isolates pressure in start tank.)

i. Record start tank pressure and time pressure was recorded.

j. Wait 15 minutes and record start tank pressure.

k. Determine pressure decay by subtracting value recorded in step j from value recorded in step i.

l. A pressure decay rate of 34 psi per hour maximum is allowable. If pressure decay exceeds this value on initial check, wait 1/2 to one hour and repeat steps i through k. If pressure decay rate is more than 34 psi per hour at the end of 3 hours, notify Engine Contractor, Field Engineering.

Operation	Result
m. Apply 550 psia maximum pneumatic pressure to START TANK VENT VALVE CONTROL customer connect.	Pressure in start tank vents from START TANK VENT & RELIEF VALVE DRAIN customer connect.
n. Leak-test flanges and connections in start tank vent valve control customer connect line.	Leakage is not allowable.

o. Decrease pneumatic pressure to START TANK VENT VALVE CONTROL customer connect to zero.

3.3.18 LEAK-TESTING START TANK DISCHARGE VALVE PISTON AND PISTON LIP SEALS (ENGINES NOT INCORPORATING MD275 CHANGE). Refer to section II for engine checkout constraints before performing this test.

a. Remove vent port check valve and packing from STDV control valve vent port.

b. Remove vent port check valve and packing from STDV piston seal vent port. Discard packing, and retain valve for reinstallation.

NOTE

The mainstage control valve is energized to prevent excess loss of helium through the engine purges.

c. Energize engine helium control, ignition phase, and mainstage control valves.

d. Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,600 psig at KSC.

e. Using pneumatic flowtester, measure and record leakage at STDV control valve vent. If no leakage is detected, STDV control valve is acceptable and STDV piston is not cracked. Perform steps f and g to verify lip seal integrity.

f. If leakage is detected at STDV control valve vent, determine specific trouble area by leak-testing STDV piston closing lip seal as follows:

(1) Using pneumatic flowtester, measure and record leakage at STDV piston seal vent port.

(2) If leakage is 40 scim or less, proceed to step g.

(3) If leakage is greater than 40 scim, deenergize engine mainstage and ignition-phase control valves.

(4) Decrease pressure to engine pneumatic system to zero.

(5) When all pressure has bled from engine, deenergize helium control valve and replace STDV as outlined in R-3825-3. Make sure replacement STDV piston has been leak tested during component testing before installation on engine.

g. Test STDV piston opening lip seal for leakage as follows:

(1) Energize STDV control valve, and using pneumatic flowtester, measure and record leakage at STDV piston seal vent port.

(2) If leakage is 40 scim or less and test is being performed to verify lip seal integrity only, proceed to step j.

(3) If leakage is 40 scim or less and test is being performed to isolate leakage detected at STDV control valve vent (step e), proceed to step h.

(4) If leakage is greater than 40 scim, deenergize engine STDV, mainstage, and ignition-phase control valves.

(5) Decrease pressure to engine pneumatic system to zero.

(6) When all pressure has bled from engine, deenergize helium control valve and replace STDV as outlined in R-3825-3. Make sure replacement STDV piston has been leak tested during component testing before installation on engine.

h. Test STDV piston for cracks, as follows:

(1) Deenergize STDV, mainstage, and ignition-phase control valves.

(2) Decrease pressure to engine pneumatic system to zero.

(3) When all pressure has bled from engine, deenergize helium control valve.

CAUTION

Distortion of engine lines can result in unsatisfactory engine operation.

(4) Disconnect control line from pneumatic opening port of STDV by removing 4 bolts, 2 washers, and one bracket. Separate control line from STDV, and remove seal. Retain bolts, washers, and bracket for reinstallation. Be extremely careful to prevent distortion of line. Remove or loosen attaching clamp, if necessary, to obtain clearance to measure leakage.

(5) Energize engine helium control, ignition phase, and mainstage control valves.

(6) Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,600 psig at KSC.

Operation	Result
(7) Verify that STDV piston seal vent port is open; then using pneumatic flowtester, measure leakage at STDV opening port. (Leakage indicates a cracked piston.)	Leakage is not allowable.

(8) If leakage is detected, deenergize ignition phase and mainstage control valves and repeat substeps 2 and 3. Replace STDV as outlined in R-3825-3. Make sure replacement STDV piston has been leak tested during component testing before installation on engine.

(9) If no leakage is detected, deenergize ignition phase and mainstage control valves and repeat substeps 2 and 3. Connect control line to STDV pneumatic opening port using new seal and one bracket, 2 washers, and 4 bolts. Torque bolts to 41-45 in-lb.

i. If test outlined in steps f through h indicates that STDV is acceptable but leakage was detected at STDV control valve vent port, leakage is within STDV control valve. If leakage from vent port of STDV control valve exceeds 15 scim, replace control valve as outlined in R-3825-3, and repeat steps d and e.

j. Install vent port check valves in STDV control valve vent port and STDV piston seal vent port. (Refer to R-3825-3.)

NOTE

Steps k through m are to be performed only if the STDV opening control line was disconnected to isolate leakage.

k. If STDV opening control line was disconnected, repeat steps c and d and energize STDV control valve.

l. Remove threaded plug from leak detection port on pneumatic control line flange at STDV opening control port (P30).

Operation	Result
m. Using pneumatic flowtester, leak-test pneumatic control line flange at STDV opening control port (P30).	Leakage is not allowable.

n. Deenergize STDV, mainstage, and ignition-phase control valves.

o. Decrease pressure to engine pneumatic system to zero.

p. When all pressure has bled from engine, deenergize helium control valve.

q. Reinstall leak detection plug and torque to 22-28 in-lb. (Safetywire plug after prelaunch leak tests.)

3.3.19 **LEAK-TESTING START TANK DISCHARGE VALVE PISTON LIP SEALS ON ENGINES WITH START TANK DISCHARGE VALVE 304386 (MD275 CHANGE).** Refer to section II for engine checkout constraints before performing this test.

a. Remove vent port check valve and packing from STDV control valve vent port.

NOTE

> The mainstage control valve is energized to prevent excess loss of helium through the engine purges.

b. Energize engine helium control, ignition-phase, and mainstage control valves.

c. Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,600 psig at KSC.

Operation	Result
d. Using pneumatic flowtester, measure leakage at STDV control valve vent port. (This is the sum of the STDV closing piston lip seal leakage and STDV control valve deenergized seat leakage.)	Maximum allowable leakage is 15 scim.
e. Energize STDV control valve, and using pneumatic flowtester, measure leakage at STDV control valve vent port. (This is the sum of the STDV opening piston lip seal leakage and STDV control valve energized seat leakage.)	Maximum allowable leakage is 15 scim.

f. Deenergize STDV, mainstage, and ignition-phase control valves.

g. Decrease pressure to engine pneumatic system to zero.

h. When all pressure has bled from engine, deenergize helium control valve.

i. If leakage in step d or step e exceeded 15 scim, perform steps j through z. If leakage was 15 scim or less, proceed to step aa.

j. Disconnect STDV opening control line from STDV. Install test plate 9025399 from test plate kit 9025400-11 between restrictor check valve and STDV. Torque bolts to 41-45 in-lb.

NOTE

> The mainstage control valve is energized to prevent excess loss of helium through the engine purges.

k. Energize engine helium control, ignition-phase, and mainstage control valves.

l. Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,600 psig at KSC.

Operation	Result
m. Using pneumatic flowtester, measure leakage at STDV control valve vent port. Record as STDV control valve deenergized seat leakage.	Maximum allowable leakage is 15 scim.

Operation	Result
n. Subtract leakage measured in step m from leakage in step d. Record as STDV closing piston lip seal leakage.	Maximum allowable leakage is 100 scim.
o. Energize STDV control valve, and using pneumatic flowtester, measure leakage at STDV control valve vent port. Record as STDV control valve energized seat leakage.	Maximum allowable leakage is 15 scim.
p. Subtract leakage measured in step o from leakage in step e. Record as STDV opening piston lip seal leakage.	Maximum allowable leakage is 100 scim.

q. Deenergize STDV, mainstage, and ignition-phase control valves.

r. Decrease pressure to engine pneumatic system to zero.

s. When all pressure has bled from engine, deenergize helium control valve.

t. Remove test plate installed in step j. Connect control line to STDV pneumatic opening port using new seal and bracket, washers, and bolts. Torque bolts to 41-45 in-lb.

u. Remove threaded plug from leak detection port on pneumatic control line flange at STDV opening control port (P30).

v. Repeat steps k and l, and energize STDV control valve.

Operation	Result
w. Using pneumatic flowtester, leak-test pneumatic control line flange at STDV opening control port (P30).	Leakage is not allowable.

x. Deenergize STDV, mainstage, and ignition-phase control valves.

y. Decrease pressure to engine pneumatic system to zero.

z. When all pressure has bled from engine, deenergize helium control valve.

aa. Install vent port check valve in STDV control valve vent port. (Refer to R-3825-3.)

ab. Reinstall leak detection plug and torque to 22-28 in-lb. (Safetywire plug after prelaunch leak tests.)

3.3.20 LEAK-TESTING START TANK DISCHARGE VALVE SWING GATE. Refer to section II for engine checkout constraints before performing this test.

3.3.20.1 Low-Pressure Leak-Testing Start Tank Discharge Valve Swing Gate.

a. On engines incorporating MD234 change, remove bolts and washers that secure drain line to STDV, and remove seal. On engines not incorporating MD234 change, remove bolts and washers that secure drain line to thrust chamber exhaust manifold, and remove seal. Be extremely careful to prevent distortion of line. Remove or loosen attaching hardware, as necessary, to obtain clearance to measure leakage.

CAUTION

Distortion of the engine lines can result in unsatisfactory engine operation.

b. Install exhaust system test plates as outlined in paragraph 3.3.3.

c. Connect a regulated supply of helium (refer to section II) capable of supplying 30 ±1 psig to one fitting of adapter 9022823, and a monitor system capable of monitoring 30 ±1 psig pressure to remaining fitting.

d. Make sure covers are removed from oxidizer and fuel turbine seal drain lines.

CAUTION

Pressure indicated on monitor gage must not exceed 35 psig any time during this test, since excessive pressure can damage the engine system.

e. Slowly adjust pressure to exhaust system until monitor system gage indicates 30 ±1 psi. Maintain 30 ±1 psig during step f.

f. Using pneumatic flowtester, measure leakage from STDV stem cavity drain port (or from drain line). Record leakage as STDV swing gate leakage at 30 psig.

g. Reduce pressure to exhaust system to zero, and vent all pressure.

h. If leakage is 20 scim or less on restart-mission engines or 200 scim or less on non-restart-mission engines, leakage is acceptable; proceed to step i or j. If leakage is excessive, proceed to paragraph 3.3.20.2.

i. On engines not incorporating MD234 change, install seal, and connect drain line to thrust chamber exhaust manifold with bolts and washers. Torque bolts to 68-72 in-lb, and safetywire.

j. On engines incorporating MD234 change, install seal, and connect drain line to STDV with bolts and washers. Torque bolts to 42-45 in-lb, and safetywire.

k. Secure engine after test as outlined in paragraph 3.3.20.3.

3.3.20.2 <u>High-Pressure Leak-Testing Start Tank Discharge Valve Swing Gate.</u> This test is required only if leakage exceeded the specified limits during the low-pressure test.

a. Remove closure from START TANK VENT & RELIEF DRAIN customer connect (or from stage drain line).

b. Remove bolts and washers that secure STDV hose to STDV. Disconnect hose and remove seal. Secure hose, as necessary, to support hose and to obtain clearance to install test plate.

c. Remove any moisture from hose inlet fitting by wiping with a clean, lint-free cloth. Discoloration on hose inlet fitting is caused by moisture and is permissible. Install protective cover on open flange of hose.

WARNING

The following procedure specifies trichloroethylene which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

- The following procedure specifies acetone which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

d. Wipe STDV gate and seat areas clean with a clean, lint-free cloth dampened with trichloroethylene or acetone.

e. Obtain test plate 9022752 from STDV adapter set 9022750-11 and the following from components adapter set 9016796:

(1) Seal RD261-3010-0070.

(2) Eight bolts NAS1006-29A.

(3) Eight washers RD153-6004-0006.

(4) Burst diaphragm assembly 19-9017276-24.

(5) Tees, reducers, and O-rings as required to connect burst diaphragm assembly and test hose to test plate 9022752.

f. Install seal RD261-3010-0070 and test plate 9022752 on outlet flange of STDV with bolts and washers from STDV adapter set 9022750. Torque bolts to 252-308 in-lb.

g. Connect a tee fitting to test plate 9022752.

h. Install burst diaphragm assembly 19-9017276-24 to one outlet of tee fitting.

i. Connect a regulated supply of helium (refer to section II) capable of supplying 500 psig to tee fitting connected to test plate 9022752. (Regulated supply of helium connected to test plate on OTBV closing control port may be used for helium supply required for this step.)

CAUTION

Pressure in excess of 500 psig can damage the start system.

j. Slowly adjust pressure to STDV outlet to 500 (+0, -20) psig. Do not exceed 500 psig.

k. Using pneumatic flowtester, measure leakage from STDV stem cavity drain port or from drain line. Record leakage as STDV swing gate leakage at 500 psig.

l. Decrease pressure to STDV to zero.

Operation	Result
m. Apply 550 psia maximum pneumatic pressure to START TANK VENT VALVE CONTROL customer connect.	Pressure in start tank vents.

n. After all pressure has vented from start tank, decrease pressure to START TANK VENT VALVE CONTROL customer connect to zero.

o. Disconnect pneumatic supply and test setup from outlet flange of STDV.

p. If leakage recorded in step k is 20 scim or less on restart-mission engines or 200 scim or less on nonrestart-mission engines, valve leakage is acceptable; proceed to step ad.

NOTE

Steps q through w replace STDV swing gate.

q. If leakage recorded in step k exceeds 20 scim on restart-mission engines or 200 scim on nonrestart-mission engines, apply pressure-sensitive tape on sealing surface of valve outlet flange to prevent damage to sealing surface when removing and installing gate.

r. Using care to prevent gate pin, tension spring, and gate from falling, force gate pin toward control valve and remove from housing; then remove tension spring and gate from housing. Note position of spring for reinstallation.

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

- The following procedure specifies acetone, which is flammable and must not be used near heat, sparks, or open flame. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury.

s. Wipe STDV housing gate seat clean with a clean, lint-free cloth dampened with trichloroethylene or acetone.

t. Inspect gate sealing surface of valve housing for damage. If damaged, proceed to step ad, complete remainder of test; then replace STDV. (Refer to R-3825-3.)

u. If gate sealing surface of valve housing is not damaged, inspect gate pin for wear or damage. If wear or damage is detected, replace gate pin.

v. Insert end of tension spring into center of gate. Install spring and new gate on valve housing by pressing gate pin (toward vent and relief valve) through lugs on housing.

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

w. Remove tape from valve outlet flange sealing surface. Clean flange sealing surface with a clean, lint-free cloth dampened with trichloroethylene.

x. Reinstall test setup on outlet flange of STDV (steps f through i).

y. Slowly adjust pressure to STDV outlet to 30 ±2 psig. Maintain 30 ±2 psig during step z.

z. Using pneumatic flowtester, measure leakage from STDV stem cavity drain port or from drain line. Record leakage as STDV swing gate leakage at 30 psig.

aa. Decrease pressure to STDV to zero.

ab. If leakage is 20 scim or less on restart-mission engines or 200 scim or less on nonrestart-mission engines, leakage is acceptable; proceed to step ad.

ac. If leakage exceeds 20 scim on restart-mission engines or 200 scim on nonrestart-mission engines, perform high-pressure test (steps j through o). During high-pressure test, if leakage is 20 scim or less on restart-mission engines or 200 scim or less on nonrestart-mission engines, leakage is acceptable; proceed to step ad. If leakage is still excessive, perform steps ad and ae; then replace STDV. (Refer to R-3825-3.)

ad. Install protective cover on START TANK VENT & RELIEF DRAIN customer connect.

ae. Disconnect helium supply and test setup from valve. If STDV hose is not to be connected, install protective cover on valve outlet flange.

af. If STDV is to be replaced, disregard steps ag through aj.

ag. Remove protective cover from STDV hose, install seal, and connect hose to STDV with bolts and washers. Torque bolts to 314-346 in-lb, and safetywire.

ah. On engines incorporating MD234 change, install seal, and connect drain line to STDV with bolts and washers. Torque bolts to 42-46 in-lb, and safetywire.

ai. On engines not incorporating MD234 change, install seal, and connect drain line to thrust chamber exhaust manifold with bolts and washers. Torque bolts to 68-73 in-lb, and safetywire.

aj. Secure engine after test as outlined in paragraph 3.3.20.3.

3.3.20.3 Securing Engine After Leak-Testing Start Tank Discharge Valve Swing Gate. Steps a through e test STDV hose-to-valve-outlet connection. If hose was not disconnected, disregard steps a through e.

a. Remove plug from STDV hose to valve outlet seal leak-test port.

CAUTION

Pressure indicated on the monitor gage must not exceed 35 psi any time during this test, since excessive pressure can damage the engine system.

b. Slowly adjust pressure to exhaust system until monitor system gage indicates 30 ±1 psi.

Operation	Result
c. Using pneumatic flowtester, measure leakage at leak-test port on valve flange.	Leakage is not allowable.

d. Decrease pressure to exhaust system to zero.

e. Install plug in leak-test port on valve outlet flange. Torque plug to 22-28 in-lb, and safetywire.

f. On engines incorporating MD234 change, proceed to step g. On engines not incorporating MD234 change, proceed to step n.

NOTE

Steps g through m test the STDV drain line connection on engines incorporating MD234 change. On engines not incorporating MD234 change, the drain line connection cannot be tested.

g. Install test adapter 9024523 from kit 9024496 on exit end of fuel turbine seal drain line.

h. Disconnect monitor system from adapter 9022823 (at torque access of fuel turbine exhaust duct) and connect to adapter 9024523. Install cap on open port of adapter 9022823.

i. Remove plug from STDV drain line seal leak-test port.

CAUTION

Pressure indicated on the regulated helium supply gage must not exceed 35 psi any time during this test, since excessive pressure can damage the engine system.

j. Slowly adjust pressure to exhaust system until regulated helium supply gage indicates 30 ±1 psi. Allow pressure indicated on monitor gage (connected to adapter on drain line exit) to stabilize.

Operation	Result
k. Using pneumatic flowtester, leak-test drain line seal leak-test port.	Leakage is not allowable.

l. Decrease pressure to exhaust system to zero, and vent all pressure from monitor system.

m. Install plug in drain line leak-test port. Torque plug to 22-28 in-lb, and safetywire.

n. Remove exhaust system test plates (paragraph 3.3.4).

NOTE

Steps o through ah leak-test the OTBV opening and closing control line flange seals. This test may be disregarded if the pneumatic control system test is to be performed.

o. Remove thrust chamber exit closure or one desiccant access cover in closure.

NOTE

Steps p through z are applicable only when testing an engine at stage static-test sites. When testing an engine at KSC, proceed to step aa.

p. Energize helium and mainstage control valves.

WARNING

Failure to observe the safety requirements of step q can result in injury to personnel.

q. Direct all personnel to stand behind adequate safety barriers or at a safe distance from engine when performing steps r through t.

r. Apply 400-1,600 psig helium pressure to helium tank.

s. Deenergize mainstage control valve.

t. Decrease helium pressure entering helium tank to 225-250 psig, and wait one minute for system pressure to bleed down to 225-250 psig.

Operation	Result
u. Using pneumatic flowtester, leak-test OTBV opening control port flange.	Leakage is not allowable.

v. Energize ignition-phase and mainstage control valves.

w. Using pneumatic flowtester, leak-test OTBV closing control line flange seal.	Leakage is not allowable.

x. Deenergize mainstage and ignition-phase control valves.

y. Decrease pressure to helium tank to zero.

z. Allow all pressure to vent from engine helium tank. Deenergize helium control valve.

NOTE

Steps aa through ag are applicable to engines at KSC only.

aa. Energize helium ignition-phase, and mainstage control valves.

ab. Apply 600-1,600 psig helium pressure to helium tank.

ac. Remove threaded plug from leak detector port and, using pneumatic flowtester, leak-test OTBV closing control port flange (P21).	Leakage is not allowable.

ad. Deenergize mainstage and ignition-phase control valves.

ae. Remove threaded plug from leak detector port and, using pneumatic flowtester, leak-test OTBV opening control port flange (P22).	Leakage is not allowable.

af. Decrease pressure to engine helium tank to zero.

ag. Allow all pressure to vent from helium tank. Deenergize helium control valve.

ah. Reinstall threaded plugs in leak detector ports and torque to 22-28 in-lb. (Safetywire plugs after prelaunch leak tests.)

3.3.21 TORQUE-TESTING OXIDIZER TURBOPUMP.

a. If hydraulic pump is not installed on accessory drive pad, carefully remove plug and seal from drive pad cover plate.

b. If hydraulic pump is installed on accessory drive pad, carefully remove torque access cover plate and plate seal from turbine exhaust hood.

c. Attach torque wrench to adapter, insert adapter into opening, and engage splines of turbine shaft and adapter. If torquing through accessory drive pad, use adapter from wrench kit 9016712-11. If torquing through torque access plate opening, use adapter from wrench kit 9017259. Refer to R-3825-3 for torque adapter conversion information.

CAUTION

A torque in excess of 1,000 in-lb can damage the turbopump.

Operation	Result
d. Rotate turbine wheel clockwise (viewed from aft end of engine), and record maximum torque required to initiate rotation as breakaway torque.	(1) Maximum allowable breakaway torque is 1,000 in-lb. (2) On SII-stage engines, maximum allowable breakaway torque is 500 in-lb if hydraulic pump is installed. If torque exceeds limit, disconnect hydraulic pump and repeat test using 1,000 in-lb limit.

NOTE

When measuring torque with the hydraulic pump installed, indicated torque must be converted to actual torque due to the effect of the torque wrench adapter.

Operation	Result
e. Continue rotating turbine slowly, and record torque required to maintain rotation as running torque.	Maximum allowable running torque is 200 in-lb.

f. Remove torque wrench and adapter from turbopump.

CAUTION

If joint connected in step g or h cannot be leak tested, condition and security of joints (section II) must be inspected and inspection recorded by each of two persons.

g. If torque access cover plate was removed, carefully install plate and seal. Torque plate mounting bolts to 40-50 in-lb. Obtain verification of acceptable condition and security of joint (section II) by each of two persons.

h. If accessory drive pad cover plug was removed, carefully install plug and seal. Torque plug to 405-445 in-lb. Obtain verification of acceptable condition and security of joint (section II) by each of two persons.

3.3.22 TORQUE-TESTING FUEL TURBOPUMP.

a. Remove plug and seal from fuel turbine torque access.

b. On engines not incorporating MD172 change, attach a torque wrench to adapter 9019861-11 from wrench kit 9016711-11, insert adapter through torque access, and engage splines of turbine shaft and adapter.

c. On engines incorporating MD172 change, attach a torque wrench to adapter 19-9025816 from wrench kit 9016711-21, insert adapter through torque access, and engage hex on turbine wheel.

CAUTION

A torque in excess of 1,000 in-lb can damage the turbopump.

Operation	Result
d. Rotate turbine wheel counterclockwise (viewed from aft end of engine), and record maximum torque required to initiate rotation as breakaway torque.	Maximum allowable breakaway torque is 1,000 in-lb.
e. Continue rotating turbine shaft slowly, and record torque required to maintain rotation as running torque.	Maximum allowable running torque is 300 in-lb.

CAUTION

Joint connected in step f cannot be leak tested, therefore condition and security of joints (section II) must be inspected and inspection recorded by each of two persons.

f. Remove wrench and adapter, and install plug and seal on torque access opening. Torque plug to 405-445 in-lb. Obtain verification of acceptable condition and security of joint (section II) by each of two persons.

3.3.23 LEAK-TESTING OXIDIZER FEED SYSTEM. Refer to section II for engine checkout constraints before performing this test. Refer to paragraph 3.3.2 for seal leak-test points.

a. Make sure engine is stabilized by one of the following methods before pressurizing oxidizer inlet duct:

(1) Engine gimbal actuator connected and locked mechanically or hydraulically.

(2) Stiff arms installed.

(3) Engine Restrainer Assembly G4066 installed and attached to test stand outriggers.

b. Remove protective closure from oxidizer turbopump intermediate seal purge check valve vent line.

c. Remove vent port check valve from boss in MFV closing control line. Connect a hand valve or install vent adapter 9025423 from vent adapter kit 9025424 in boss. Close hand valve.

d. On engines not incorporating MD301, MD302, MD322, or MD323 change, disconnect purge control valve vent line and install test plate 9025399 from test plate kit 9025400-11. Torque bolts to 41-45 in-lb.

e. Disconnect pneumatic inlet line, and remove seal from inlet port of purge control valve. Install test plate 9025399 from test plate kit 9025400-11 between pneumatic line and valve inlet port. Torque bolts to 41-45 in-lb.

f. Make sure oxidizer turbopump primary seal drain line is not capped (stage overboard line on engines incorporating MD301, MD302, MD322, or MD323 change).

g. Install exhaust system test plates (paragraph 3.3.3).

NOTE

The thrust chamber throat plug must be installed to measure main oxidizer valve gate seal leakage.

h. Install Presstite tape, Type 587.3 (Interchemical Corp), and cover with 2-inch-wide Teflon Temp-R-Tape, Type C (Connecticut Hard Rubber Co), in thrust chamber throat plug seating area as follows:

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

(1) Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe a 4-inch portion of thrust chamber throat approximately 9 inches down from injector face or approximately 4 inches from throat.

(2) Cut two 28 ±1 inch pieces of 1/2-inch-wide Presstite tape.

(3) Cover Presstite tape with Teflon Temp-R-Tape. Press tape slightly to make sure tape sticks to Presstite tape.

(4) Remove paper backing from the 2 strips of tape, and install tape around inside of thrust chamber throat approximately 11 inches from face of injector or approximately 6 inches from throat. Trim ends, as necessary, to make one continuous band of tape. Make sure tape ends are pressed firmly together. Press tape slightly with fingers as required, to make tape stay in place.

(5) Cut a 4-inch piece of Presstite tape. Place tape on workbench with paper backing facing workbench. Cut tape into 2 pieces 1/4-inch wide by 4 inches in length.

(6) Place throat plug half that contains burst diaphragm on workbench with flat up. Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe flat.

(7) Install the two 4-inch pieces of tape on flat of throat plug. Stretch each piece to width of flat, and install on each side of hole to form 2 seals on flat. Cover each piece of Presstite tape with Teflon Temp-R-Tape. Press tape slightly with fingers, as required, to make tape stay in place. Trim ends of tape at each end flush with edge of flat.

NOTE

Thrust Chamber Throat Plug Kit G3120MD3 must be installed dry (no lubricant).

i. Place hand screw in throat plug in stowed position to prevent movement during plug installation.

j. Install half of throat plug into thrust chamber combustion area with handle-equipped end facing thrust chamber exit. Make sure throat plug half does not disturb tape.

k. Install other half of throat plug, and mate halves of plug. Make sure tape strips on flat stay in place during plug installation.

l. Grasp handles, and pull sections together toward throat area until a tight fit is obtained.

m. Remove plug from monitor port on thrust chamber throat plug.

n. On engines not incorporating MD366 or MD371 change, remove shaft seal vent port check valve from PU valve. On engines incorporating MD366 or MD371 change, remove vent port check valve from port A of MRCV.

o. Install test adapters 9024523 on exit end of fuel turbine seal drain line and on oxidizer turbine seal drain line.

p. On engines not incorporating MD234 change, disconnect STDV drain line from thrust chamber exhaust manifold. Install leak test kit EWR225310 between line flange and thrust chamber exhaust manifold. Torque nuts to 41-45 in-lb.

q. Remove threaded plugs from leak detection ports as required during system test. (See figure 3-32.)

r. Verify that oxidizer chilldown return system is closed; then slowly pressurize engine oxidizer feed system to 30 ±5 psig.

Operation	Result
s. Leak-test the following connections:	Leakage is not allowable.

(1) Stage to oxidizer inlet duct interface flange.

(2) Oxidizer inlet duct to turbopump (L1).

(3) ON SII stage engines, LOX BLEED LINE customer connect interface.

(4) MOV upstream flange (L21).

(5) ASI valve flange to MOV body (L22).

(6) On engines not incorporating MD105 or MD194 change, line connection on oxidizer high-pressure duct (L12).

(7) On engines incorporating MD105 or MD194 change, oxidizer high-pressure duct heat exchanger supply port plate (L12).

(8) Oxidizer turbopump to oxidizer high-pressure duct (L10).

(9) Oxidizer high-pressure duct blank flange (L20).

(10) Oxidizer flowmeter flange (L14).

(11) Oxidizer bleed valve to oxidizer high-pressure duct (L17).

(12) GG oxidizer line to GG (L28).

(13) On engines not incorporating MD366 or MD371 change, PU valve inlet to turbopump outlet manifold (L8) or on engines incorporating MD366 or MD371 change, MRCV inlet to turbopump outlet manifold (L8).

(14) On engines not incorporating MD366 or MD371 change, PU valve to PU valve actuator (L7) or on engines incorporating MD366 or MD371 change, MRCV pneumatic actuator housing to valve gate housing (L7).

(15) On engines not incorporating MD366 or MD371 change, PU valve outlet to turbopump (L5) or on engines incorporating MD366 or MD371 change, MRCV outlet to turbopump (L5).

(16) On SII stage engines, oxidizer bleed valve to oxidizer bleed line (L16).

Operation	Result
t. Using helium leak detector, leak-test braided section of the following lines:	Leak is not allowable.

(1) On SII Stage engines, oxidizer bleed line to customer connect.

(2) Heat exchanger oxidizer supply line to oxidizer high-pressure duct.

(3) Oxidizer bleed valve line to GG.

u. Leak-test connecttions of the following instrumentation lines to primary and auxiliary FI packages:	Leakage is not allowable.

(1) Oxidizer turbopump discharge lines PO3 (primary package) (L13).

(2) On engines not incorporating MD269, MD282, MD296, MD313, or MD315 change, oxidizer pump bearing coolant line PO7 (L41) (auxiliary package).

(3) On engines not incorporating MD366 or MD371 change, PU valve inlet pressure line PO8 (L9) or on engines incorporating MD366 or MD371 change, MRCV inlet pressure line PO8 (L9) auxiliary package).

(4) On engines not incorporating MD366 or MD371 change, PU valve outlet pressure line PO9 (L6) or on engines incorporating MD366 or MD371 change, MRCV outlet pressure line PO9 (L6) (auxiliary package).

(5) On SII stage, heat exchanger oxidizer inlet pressure line HO1 (auxiliary package) (L23).

Operation	Result
v. On engines incorporating MD150, MD280, or MD281 change, leak-test instrumentation ports. On engines not incorporating MD150, MD280, or MD281 change, leak-test connections of the following stage static-test instrumentation lines:	Leakage is not allowable.

(1) On engines not incorporating MD237 change, oxidizer turbopump discharge pressure line PO2 (L11) from oxidizer turbopump outlet to static-test transducer.

(2) On engines incorporating MD237 change, oxidizer turbopump discharge pressure line from tee in line PO3 to static-test transducer.

(3) Oxidizer pump bearing coolant pressure line from tee in line PO7 to static-test transducer.

Operation	Result
w. Leak-test the following instrumentation taps:	Leakage is not allowable.

(1) Oxidizer turbopump discharge port (L11).

(2) Oxidizer turbopump discharge fluid-temperature transducer located on high-pressure duct (L15).

(3) Oxidizer temperature transducer located on oxidizer bleed valve (L18).

(4) Capped port (GO2) on oxidizer bleed valve (L19).

x. If hydraulic pump is not installed on accessory drive pad, carefully remove plug and seal from drive pad cover plate.

y. If hydraulic pump is installed on accessory drive pad, carefully remove torque access cover plate and plate seal from turbine exhaust hood.

z. If torquing through accessory drive pad, use adapter 9010875-11 from wrench kit 9016712-11. If torquing through torque access plate opening, use adapter from wrench kit 9017259. Attach torque wrench to adapter, insert adapter into opening, and engage splines of turbine shaft and adapter.

CAUTION

A torque in excess of 1,000 in-lb can damage the turbopump.

Operation	Result
aa. Using pneumatic flowtester to measure leakage from oxidizer turbopump primary seal drain line (on engines incorporating MD301, MD302, MD322, or MD323 change), measure leakage at stage overboard line exit; rotate turbine wheel clockwise (viewed from aft end of engine) a minimum of 5 complete revolutions to determine maximum leakage point. Continue to rotate turbopump to position where maximum leakage is noted. Record as oxidizer turbopump primary seal leakage.	Maximum allowable leakage is 350 scim.
ab. Using pneumatic flowtester, measure leakage from fitting of test adapter installed on torque access of fuel turbine exhaust duct. Keep flowtester connected to fitting for a minimum of 10 minutes and until flowmeter stabilizes. Record leakage as oxidizer turbopump shaft seal and GG control valve oxidizer poppet combined leakage.	Maximum allowable leakage is 1.5 scim.

ac. If leakage measured in step ab was more than 1.5 scim, decrease pressure to oxidizer turbopump inlet to zero and isolate leakage as outlined in paragraph 3.3.23.1. If leakage was 1.5 scim or less, proceed to step ad.

Operation	Result
ad. On engines not incorporating MD366 or MD371 change, using pneumatic flowtester, measure leakage at PU valve vent port. Record as PU valve shaft seal leakage.	Maximum allowable leakage is 10 scim.
adA. On engines incorporating MD366 or MD371 change, using pneumatic flowtester, measure leakage at MRCV vent port (port A). Record as MRCV shaft seal leakage. If leakage exceeds 10 scim, verify MRCV shaft seal leakage at 30 (+5, -1) psig before replacing MRCV.	Maximum allowable leakage is 10 scim.

NOTE

Oxidizer feed system should be pressurized for at least 5 minutes before performing step ae.

Operation	Result
ae. Using pneumatic flowtester, measure leakage at thrust chamber throat plug monitor port. (This is the combined MOV gate and ASI valve seat leakage.) If leakage exceeds 10 scim, perform steps af through ai. If leakage is 10 scim or less, proceed to step aj.	Maximum allowable leakage is 10 scim.

af. Disconnect ASI oxidizer line from ASI valve inlet, and install test plate 0025300 from test plate kit 0025400-11 between line and valve. Torque bolts to 41-45 in-lb.

NOTE

Oxidizer feed system should be pressurized for at least 5 minutes before performing step ag.

Operation	Result
ag. Using pneumatic flowtester, measure leakage at thrust chamber throat plug monitor port. Record MOV gate seal leakage.	Maximum allowable leakage is 10 scim.
ah. Subtract leakage measured in step ag from combined leakage recorded in step ae. Record as ASI valve seat leakage.	Maximum allowable leakage is 10 scim.

ai. Remove test plate installed in step af, and reconnect ASI oxidizer line to ASI valve outlet using new seal. Torque bolts to 41-45 in-lb and safetywire. (Flange connection must be leak tested during thrust chamber leak test.)

NOTE

The burst diaphragm is removed to prevent accidental pressurization of the thrust chamber.

aj. If throat plug is to remain installed for thrust chamber repressurizing, remove burst diaphragm from throat plug until repressurization is required. (When reinstalling burst diaphragm, torque to 135-165 in-lb.) If throat plug is to be removed, proceed as follows:

(1) Move hand screw on throat plug from stowed position to operating position, and rotate hand screw until one half of throat plug slides forward. Place hand screw in stowed position.

(2) Push throat plug into combustion area.

(3) Rotate one half of throat plug and disengage from pivot.

(4) Remove throat plug sections from thrust chamber.

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

ak. Remove tape from thrust chamber throat and throat plug. Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe throat area where tape was installed, to make sure area is clean.

al. Energize engine helium control valve.

am. Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,000 psig at KSC.

Operation	Result
an. Using pneumatic flowtester, measure leakage from LOX BLEED LINE customer connect. Record as oxidizer bleed valve leakage. (Verify that leakage is not coming from stage oxidizer chilldown return system.)	Maximum allowable leakage is 300 scim.
ao. Decrease pressure to oxidizer pump inlet to zero.	Oxidizer feed system depressurizes.

ap. Using pneumatic flowtester, measure leakage from oxidizer turbopump primary seal drain. (On engines incorporating MD301, MD302, MD322, or MD323 change, measure leakage at stage overboard line exit.) Record as oxidizer turbopump intermediate seal leakage (pump direction).

aq. Using pneumatic flowtester, measure leakage from oxidizer turbine seal drain line. Record as oxidizer intermediate seal leakage (turbine direction).

NOTE

Step ar is not a scheduled requirement at KSC. It is provided if required for an unscheduled task.

ar. Using pneumatic flowtester and adapter 008133, measure flow downstream of oxidizer turbopump intermediate seal purge check valve. Record flow.

as. Add values recorded in steps ap, aq, and ar. Record as oxidizer turbopump intermediate seal purge flow. Sum must be as follows:

(1) At stage test sites, sum must be 1,500 scim minimum.

NOTE

Substep (2) is not a scheduled requirement at KSC. It is provided if step ar is performed for an unscheduled task.

(2) At KSC, sum must be 2,000-7,000 scim.

at. Add values of steps ap and aq. Sum must not exceed 850 scim. Record as oxidizer turbopump intermediate seal leakage.

au. Shut off helium supply to engine helium tank.

Operation	Result
av. Use hand valve or vent adapter 9025423 in boss in MFV closing control line to vent pressure from control system. After all pressure has vented, close hand valve.	Helium tank depressurizes.

aw. Deenergize engine helium control valve.

ax. Remove torque wrench and adapter from turbopump.

CAUTION

Joint connected in step ay or az cannot be leak tested, therefore condition and security of joints (section II) must be inspected and inspection recorded by each of two persons.

ay. If torque access cover plate was removed, carefully install plate and seal. Torque plate mounting bolts to 40-50 in-lb. Obtain verification of acceptable condition and security of joint (section II) by each of two persons.

az. If accessory drive pad cover plug was removed, carefully install plug and seal. Torque plug to 405-445 in-lb. Obtain verification of acceptable condition and security of joint (section II) by each of two persons.

ba. Remove exhaust system test plates (paragraph 3.3.4).

bb. Remove hand valve or vent adapter from boss in MFV closing control line.

bc. Install vent port check valve into boss in MFV closing control line. (Refer to R-3825-3.)

bd. Remove test adapters from exit end of fuel turbine drain line and oxidizer turbine drain line.

be. On engines not incorporating MD234 change, remove bolts and washers that secure STDV drain line to thrust chamber exhaust manifold, and remove test plate.

bf. On engines not incorporating MD234 change, install new seal and connect STDV drain line to thrust chamber exhaust manifold with bolts and washers. Torque bolts to 60-73 in-lb, and safetywire.

bg. On engines not incorporating MD301, MD302, MD322, or MD323 change, remove test plate kit 9025400-11, install new seal, and connect vent line to purge control valve. Torque bolts to 41-45 in-lb.

bh. Energize engine helium control valve.

bi. Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,600 psig at KSC.

Operation	Result
bj. Using pneumatic flowtester, leak-test OTBV opening control port.	Leakage is not allowable.

bk. Energize ignition-phase and mainstage control valves.

Operation	Result
bl. Using pneumatic flowtester, leak-test OTBV closing control port flange.	Leakage is not allowable.

bm. Deenergize ignition-phase and mainstage control valves.

bn. Decrease pressure to helium tank to zero.

bo. Allow all pressure to vent from helium tank. Deenergize helium control valve.

bp. Remove test plate kit 9025400-11 from between inlet port of purge control valve and inlet line. Install new seal, and connect line to inlet port of purge control valve. Torque bolts to 41-45 in-lb.

bq. Energize helium and mainstage control valves.

br. Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,600 psig at KSC.

Operation	Result
bs. Using pneumatic flowtester, leak-test purge control valve inlet port flange.	Leakage is not allowable.

bt. Deenergize mainstage control valve.

bu. Decrease pressure to helium tank to zero.

bv. Allow all pressure to vent from helium tank. Deenergize helium control valve.

bw. Reinstall PU valve or MRCV vent port check valve. (Refer to R-3825-3.)

bx. Install thrust chamber exit closure. (Tighten nuts handtight plus 1/4 turn.) If thrust chamber diffuser is installed, secure exit closure with 20 tension springs RD395-44050.

by. Reinstall threaded plugs in leak detection ports and torque to 22-28 in-lb. (Safetywire plugs after prelaunch leak tests.)

CAUTION

Misalined Naflex seals at instrumentation ports can result in leakage and possible damage to the engine.

bz. On engines incorporating MD150, MD280, or MD281 change and not incorporating MD237 change, verify that Naflex seal at instrumentation port PO2 is concentric with plug. (Refer to R-3825-3.) On engines not incorporating MD237 change, verify that Naflex seal at instrumentation port GO2 is concentric with plug. (Refer to R-3825-3.)

3.3.23.1 Isolating and Leak-Testing Gas Generator Control Valve Oxidizer Poppet. This test is to be performed only if the combined GG control valve oxidizer poppet and oxidizer turbopump shaft seal leakage recorded in paragraph 3.3.23 exceeds the maximum allowable value.

a. Disconnect oxidizer bleed valve from high-pressure duct.

b. Install test plate 9022534 from bleed valve adapter set 0022447-11 (components adapter set 0016700) on oxidizer inlet flange of bleed valve. Torque bolts to 61-75 in-lb.

c. Connect a regulated supply of helium (refer to section II) capable of supplying 0-100 psig to test plate 9022534.

d. Slowly increase pneumatic pressure to bleed valve inlet to 30 ±1 psig.

Operation	Result
e. Using pneumatic flowtester, measure leakage from fitting of test adapter installed on torque access of fuel turbine exhaust duct. Keep flowtester connected to fitting for a minimum of 10 minutes and until flowmeter stabilizes. Record leakage as GG control valve oxidizer poppet leakage.	Maximum allowable leakage is 1.5 scim.

f. Subtract value recorded in step e from value of combined oxidizer turbopump shaft seal and GG control valve oxidizer poppet leakage recorded in paragraph 3.3.23. Result must be 20 scim or less. If a negative result is obtained, record as zero. Record resultant value as oxidizer turbopump shaft seal leakage.

g. Decrease pressure to oxidizer bleed valve inlet to zero.

h. Disconnect pneumatic source from test plate on bleed valve; then remove test plate.

i. Install oxidizer bleed valve on high-pressure duct, and cross-torque bolts to 143-157 in-lb; then safetywire.

j. Remove threaded plugs from leak detection ports, as required, for system test. (See figure 3-32.)

k. Slowly pressurize engine oxidizer feed system to 30 ±1 psig.

l. Leak-test the following connections and instrumentation taps:	Leakage is not allowable.

(1) Oxidizer bleed valve to oxidizer high-pressure duct (L17).

(2) GG oxidizer line to GG (L28).

(3) Oxidizer bleed valve to oxidizer bleed line (L16).

(4) Oxidizer temperature probe located on oxidizer bleed valve (L18).

(5) Capped port (GO2) on oxidizer bleed valve (L19).

m. Continue oxidizer feed system leak test starting with paragraph 3.3.23, step ad.

n. Reinstall threaded plugs in leak detection ports and torque to 22-28 in-lb. (Safetywire plugs after prelaunch tests.)

3.3.24 TESTING OXIDIZER TURBOPUMP PRIMARY SEAL DRAIN LINE BURST DIAPHRAGM.

a. Leak-test test fixture KSC-J2-R066907 as follows:

(1) Install hydrometer bulb on needle valve, and open valve 1/4 to 1/2 turn.

(2) Compress bulb and close Tygon tube at drain line attach point to preclude leakage.

(3) While observing test indicator pin, release bulb to evacuate test chamber; when pin is retracted, close needle valve. Monitor indicator pin for one minute; indicator pin must not move.

b. Remove protective closure from oxidizer turbopump primary seal drain line.

c. Open test fixture needle valve 1/4 to 1/2 turn, and install test fixture on oxidizer turbopump primary seal drain line. Close needle valve.

d. Compress bulb and install on needle valve; then release bulb.

e. Open needle valve 1/4 to 1/2 turn and evacuate test fixture and drain line.

f. Verify that indicator pin has retracted; then close needle valve, and remove bulb from test fixture. If indicator pin does not retract, perform steps h through j. If indicator pin retracts, burst diaphragm is acceptable; proceed to step k.

g. (Deleted)

h. Install Presstite tape, Type 587.3 (Interchemical Corp) across connection between diaphragm retainer fitting to exit tube retainer nut, and over inspection slot in diaphragm retainer fitting. (See figure 3-46.)

i. Repeat steps c through f. If indicator pin does not retract, burst diaphragm is not acceptable.

j. Remove Presstite tape.

k. Open needle valve 1/4 to 1/2 turn, and remove test fixture from drain line.

l. Install protective closure ST3050263RKL on drain line.

3.3.25 LEAK-TESTING FUEL FEED SYSTEM. Refer to section II for engine checkout constraints before performing this test. Refer to paragraph 3.3.2 for engine seal leak-test points.

a. Make sure engine is stabilized by one of the following methods before pressurizing fuel inlet duct:

(1) Engine gimbal actuator connected and locked mechanically or hydraulically.

(2) Stiff arms installed.

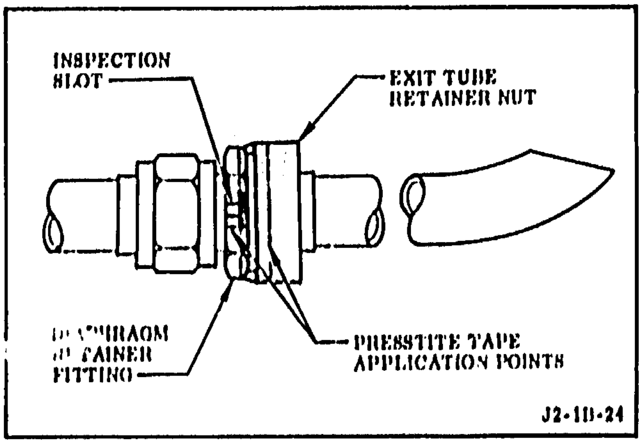


Figure 3-46. Tape Application Points for Leak-Testing Burst Diaphragm

(3) Engine Restrainer Assembly G4066 installed and attached to test stand outriggers.

b. Remove vent port relief valve from boss in MFV closing control line. Connect hand valve or vent adapter 9025423 from vent adapter kit 9025423 in boss; torque to 40-65 in-lb. Close hand valve.

NOTE

The hand valve or adapter is used to eliminate the flow of helium to prevent depletion of facility helium supply.

c. Remove protective closures from oxidizer turbopump primary seal drain and oxidizer turbine seal drain line.

d. Disconnect pneumatic inlet line, and remove seal from inlet port of purge control valve. Install test plate 9025399 from test plate kit 9025400 between line and valve inlet port. Torque bolts to 40-45 in-lb.

e. Remove plug and seal from boss between fuel turbopump and fuel turbopump primary seal drain check valve.

f. Install exhaust system test plates (paragraph 3.3.3).

NOTE

The thrust chamber throat plug must be installed to measure main fuel valve gate seal leakage.

g. Install Presstite tape, Type 587.3 (Interchemical Corp), and cover with 2-inch-wide Teflon Temp-R-Tape, Type C (Connecticut Hard Rubber Co), in thrust chamber throat plug seating area as follows:

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

(1) Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe a 4-inch portion of thrust chamber throat approximately 9 inches down from injector face or approximately 4 inches from throat.

(2) Cut two 28 ±1 inch pieces of 1/2-inch-wide Presstite tape.

(3) Cover Presstite tape with Teflon Temp-R-Tape. Press tape slightly to make sure tape sticks to Presstite tape.

(4) Remove paper backing from the 2 strips of tape, and install tape around inside of thrust chamber throat approximately 11 inches from face of injector or approximately 6 inches from throat. Trim ends, as necessary, to make one continuous band of tape. Make sure tape ends are pressed firmly together. Press tape slightly with fingers, as required, to make tape stay in place.

(5) Cut a 4-inch piece of Presstite tape. Place tape on workbench with paper backing facing workbench. Cut tape into 2 pieces 1/4-inch-wide by 4 inches in length.

(6) Place throat plug half that contains burst diaphragm on workbench with flat up. Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, hand-wipe flat.

(7) Install the two 4-inch pieces of tape on flat of throat plug. Stretch each piece to width of flat, and install on each side of hole to form 2 seals on flat. Cover each piece of Presstite tape with Teflon Temp-R-Tape. Press tape slightly with fingers, as required, to make tape stay in place. Trim ends of tape at each end flush with edge of flat.

NOTE

Thrust Chamber Throat Plug Kit G3120MD3 must be installed dry (no lubricant).

h. Place hand screw in throat plug in stowed position to prevent movement during plug installation.

i. Install half of throat plug into thrust chamber combustion area with handle-equipped end facing thrust chamber exit. Make sure throat plug half does not disturb tape.

j. Install other half of throat plug, and mate halves of plug. Make sure tape strips on flat stay in place during plug installation.

k. Grasp handles, and pull sections together toward throat area until a tight fit is obtained.

l. Remove plug from monitor port on thrust chamber throat plug.

m. Remove threaded plugs from leak detection ports as required for system test. (See figure 3-32.)

n. Verify that fuel chilldown return system is closed; then slowly pressurize engine fuel system to 30 ±5 psig.

Operation	Result
o. Leak-test the following connections:	Leakage is not allowable.

(1) Stage to fuel inlet duct interface flange.

(2) Fuel inlet duct to turbopump (F9).

(3) On SII stage engines, FUEL BLEED LINE customer connect interface.

(4) On SII stage engines, fuel bleed valve to fuel bleed line (F18).

(5) Fuel turbopump volute to support (below pump volute) (F12).

(6) Fuel turbopump to fuel high-pressure duct (F14).

(7) MFV upstream flange (F6).

(8) Fuel flowmeter flange (F22).

(9) Fuel high-pressure duct to fuel bleed valve adaptor (F20).

(10) Fuel bleed valve adaptor to fuel bleed valve (F19).

(11) GG fuel supply line to GG (F8).

(12) Fuel turbine seal purge TG10 (F46).

(13) Fuel turbopump balance piston pump pressure at capped line PF4 (F47).

(14) Fuel turbopump primary seal purge PF7 (F48).

Operation	Result
p. Using helium leak-detector, leak-test the following lines:	Leakage is not allowable.

(1) On SII stage engines, fuel bleed line to customer connect.

(2) Fuel high-pressure duct (all insulation joints and seams).

(3) GG fuel supply line to GG.

Operation	Result
q. Leak-test connections of the following instrumentation lines to primary and auxiliary FI packages:	Leakage is not allowable.

(1) Fuel turbopump discharge pressure line PF3 (primary package) (F21).

(2) Fuel turbopump balance piston cavity pressure line PF5 (auxiliary package) (F45).

Operation	Result
r. On engines not incorporating MD233 change, leak-test fuel turbopump interstage pressure line PF6 (F10) from turbopump to transducer.	Leakage is not allowable.
s. On engines not incorporating MD150, MD280, or MD281 change, leak-test connections of the following stage static-test instrumentation lines:	Leakage is not allowable.

(1) Fuel turbopump balance piston cavity pressure line from tee in line PF5 to static-test transducer.

(2) Fuel turbopump discharge pressure line PF2 (F15) from turbopump outlet to static-test transducer. On engines incorporating MD150, MD280, or MD281 change, leak-test at line PF2 instrumentation port.

Operation	Result
t. Leak-test the following instrumentation taps:	Leakage is not allowable.

(1) Turbopump rear bearing temperature transducer at PST1 tap (F11).

(2) GG fuel inlet temperature transducer (F17) (on fuel bleed valve).

(3) Capped port (F16) on fuel bleed valve.

(4) Fuel turbopump discharge-fluid temperature transducer (F13).

(5) Fuel turbopump discharge-fluid temperature transducer (F7) (downstream of flowmeter).

(6) Fuel turbopump interstage pressure instrumentation port PF6 (F10).

u. Remove adapter 9022823 from torque access of turbine exhaust duct.

v. On engines not incorporating MD172 change, install torque wrench to adapter 9010861-11 from wrench kit 9010711-11, insert through torque access, and engage splines of turbine shaft and adapter.

w. On engines incorporating MD172 change, install torque wrench to adapter 10-0025810 from wrench kit 9010711-21, insert through torque access, and engage hex on turbine wheel.

CAUTION

A torque in excess of 1,000 in-lb can damage the turbopump.

Operation	Result
x. Using pneumatic flowtester to measure leakage from boss between fuel turbopump	For allowable leakage limits see figure 3-47 for SIVB-stage engines and

Operation	Result
and fuel turbopump drain check valve, rotate turbine wheel counterclockwise (viewed from aft end of engine) a minimum of 5 complete revolutions to determine maximum leakage point. Continue to rotate pump to position of maximum leakage, and record leakage as fuel turbopump primary seal leakage.	figures 3-48 and 3-49 for SII-stage installed engines.

y. Remove torque wrench and adapter, and reinstall adapter 9022823 in torque access of fuel turbine exhaust duct. Torque adapter to 40-60 in-lb.

z. Using pneumatic flowtester, measure leakage from fitting of test adapter 9022823 installed on torque access of fuel turbine exhaust duct. Record as fuel turbopump omni seal and GG fuel poppet combined leakage.	Maximum allowable leakage is 15 scim.

NOTE

Fuel feed system should be pressurized for at least 5 minutes before performing step aa.

aa. Using pneumatic flowtester, measure leakage at thrust chamber throat plug monitor port. Record as MFV gate seal leakage.	Maximum allowable leakage is 10 scim.

NOTE

The burst diaphragm is removed to prevent accidental pressurization of the thrust chamber.

ab. If throat plug is to remain installed for subsequent thrust chamber repressurizing, remove burst diaphragm from throat plug until repressurization is required. (When reinstalling burst diaphragm, torque to 135-165 in-lb). If throat plug is to be removed, proceed as follows:

(1) Move hand screw on throat plug from stowed position to operating position, and rotate hand screw until one half of throat plug slides forward. Place hand screw in stowed position.

(2) Push throat plug into combustion area.

(3) Rotate one half of throat plug and disengage from pivot.

(4) Remove throat plug sections from thrust chamber.

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

ac. Remove tape from thrust chamber throat and throat plug. Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe throat area where tape was installed, to make sure area is clean.

ad. On engines incorporating MD301, MD302, MD322, or MD323 change, make sure stage overboard line from oxidizer turbopump primary seal drain is not capped.

ae. Energize engine helium control valve.

af. Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 900-1,600 at KSC.

Secondary Seal Helium Leakage	Primary Seal Helium Leakage		
	10 SCIM or Less	Greater Than 10 SCIM But Less Than or Equal to 350 SCIM	Greater Than 350 SCIM
110 SCIM or Less	Acceptable	Acceptable	Replace primary seal.[a]
Greater Than 110 SCIM But Less or Equal to 500 SCIM	Acceptable	Replace secondary seal.[a]	Replace primary and secondary seals.[a]
Greater Than 500 SCIM	Replace secondary seal.[a]	Replace secondary seal.[a]	Replace primary and secondary seals.[a]

(a) Refer to R-3825-3.

Figure 3-47. Allowable Fuel Turbopump Primary and Secondary Seal Leakages and Replacement Criteria for SIVB-Stage Engines

Secondary Seal Helium Leakage	Primary Seal Helium Leakage		
	9 SCIM or Less	Greater Than 9 SCIM But Less Than or Equal to 350 SCIM	Greater Than 350 SCIM
75 SCIM or Less	Acceptable	Acceptable	Replace primary seal.[b]
Greater Than 75 SCIM But Less or Equal to 500 SCIM	Acceptable	(a)	Replace primary and secondary seals.[b]
Greater Than 500 SCIM	Replace secondary seal.[b]	Replace secondary seal.[b]	Replace primary and secondary seals.[b]

(a) Using measured leakage past both seals and figure 3-40, determine equivalent hydrogen boattail leakage for each turbopump. Total equivalent boattail leakage for five turbopumps must not exceed 45,000 scim. Replace one or more secondary seals until total leakage is equal to or less than 45,000 scim.
(b) Refer to R-3825-3.

Figure 3-48. Allowable Fuel Turbopump Primary and Secondary Seal Leakages and Replacement Criteria for SII-Stage Engines

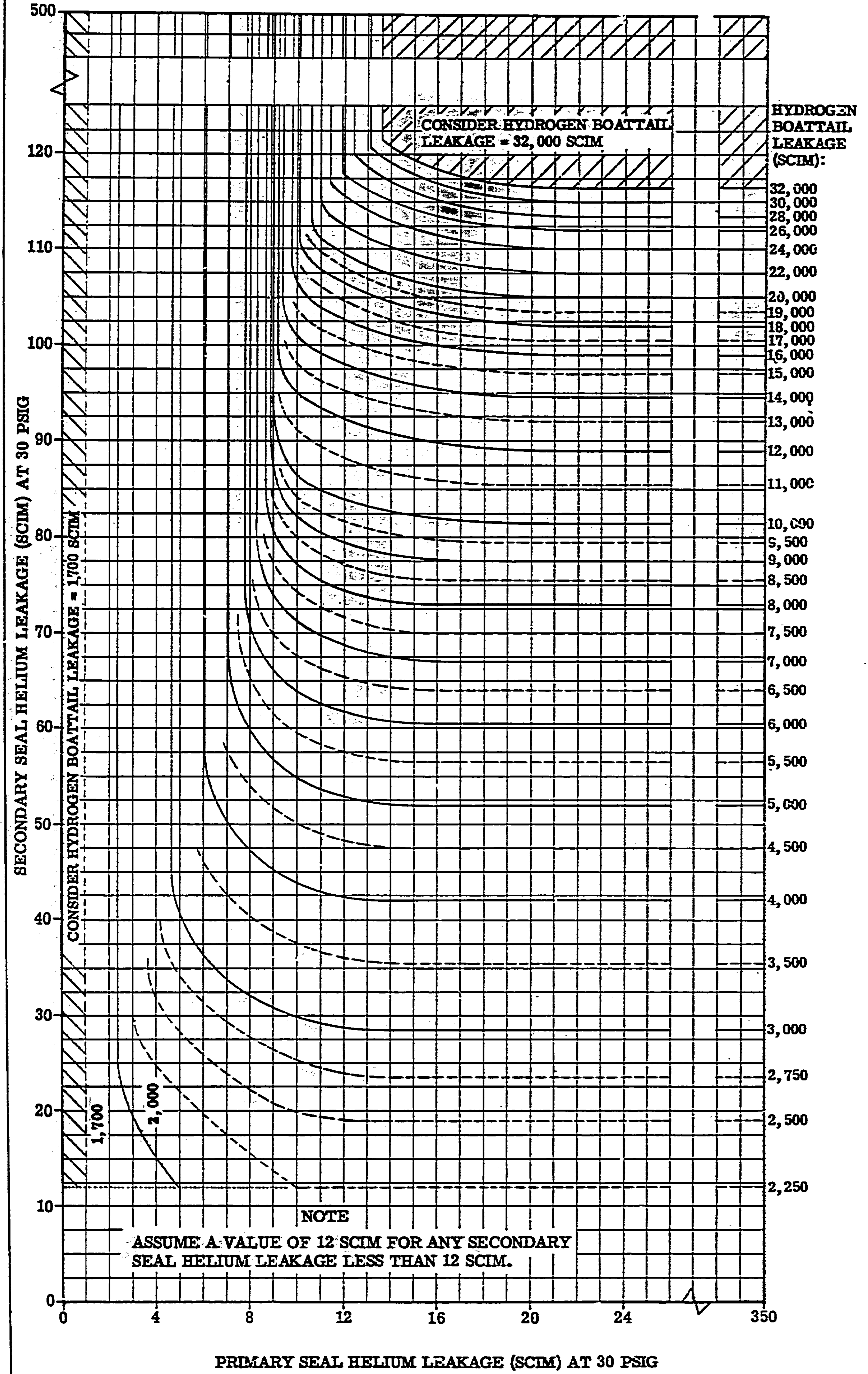


Figure 3-40. Fuel Turbopump Hydrogen Boattail Leakage at 120 Seconds After Lift-Off (SII-Stage Single Engine)

Operation	Result
ag. Using pneumatic flowtester, measure fuel bleed valve leakage from fuel bleed line. Record as fuel bleed valve leakage. (Verify that leakage is not coming from stage fuel chilldown return system.)	Maximum allowable leakage is 300 scim.

ah. Shut off pneumatic pressure to engine helium tank.

ai. Using hand valve or vent adapter 9025423 in boss in MFV control line, vent pressure from control system. After all pressure has vented, close hand valve.

aj. Deenergize helium control valve.

ak. Decrease fuel feed system pressure to zero.

al. Install plug and seal in boss between fuel turbopump and turbopump drain check valve. Torque plug to 65-70 in-lb.

am. Remove hand valve or vent adapter 9025423 from boss in MFV closing control line.

an. Install vent port check valve into boss in MFV closing control line. (Refer to R-3825-3.)

ao. Remove adaptor 9022823 from torque access of fuel turbine exhaust duct. Install plug and new seal in torque access opening. Torque plug to 405-445 in-lb.

ap. Remove exhaust system test plates (paragraph 3.3.4).

aq. Energize engine helium control valve.

ar. Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,600 psig at KSC.

Operation	Result
as. Using pneumatic flowtester, leak-test OTBV opening control port flange.	Leakage is not allowable.

at. Energize ignition-phase and mainstage control valves.

Operation	Result
au. Using pneumatic flowtester, leak-test OTBV closing control port flange.	Leakage is not allowable.

av. Deenergize ignition-phase and mainstage control valves.

aw. Decrease pressure to helium tank to zero.

ax. Allow all pressure to vent from helium tank. Deenergize helium control valve.

ay. Remove test plate kit 9025400-11 from between inlet port of purge control valve and inlet line. Install new seal, and connect line to inlet port of purge control valve. Torque bolts to 41-45 in-lb.

az. Energize helium and mainstage control valves.

ba. Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,600 psig at KSC.

Operation	Result
bb. Using pneumatic flowtester, leak-test purge control valve inlet port flange.	Leakage is not allowable.

bc. Deenergize mainstage control valve.

bd. Decrease pressure to helium tank to zero.

be. Allow all pressure to vent from helium tank. Deenergize helium control valve.

bf. Apply 97-115 psig helium pressure through PURGE MANIFOLD SYSTEM pneumatic supply line.

Operation	Result
bg. Leak-test fitting in boss between fuel turbopump and fuel turbopump primary seal drain check valve.	Leakage is not allowable.

bh. Decrease pneumatic pressure to PURGE MANIFOLD SYSTEM to zero.

bi. Reinstall threaded plugs in leak detection ports and torque to 22-28 in-lb. (Safetywire plugs after prelaunch leak tests.)

CAUTION

Misalined Naflex seals at instrumentation ports can result in leakage and possible damage to the engine.

biA. On engines not incorporating MD237 change, verify that Naflex seal at instrumentation port GF5 is concentric with plug. (Refer to R-3825-3.)

bj. Install protective closures on oxidizer and fuel turbopump primary seal drain lines and oxidizer and fuel turbine seal drain lines.

bk. Install thrust chamber exit closure. (Tighten nuts handtight plus 1/4 turn.) If thrust chamber diffuser is installed, secure exit closure with 20 tension springs RD305-44050.

3.3.25A LEAK-TESTING OXIDIZER AND FUEL INLET DUCT TORSIONAL BELLOWS.

a. Obtain the following test equipment, or equivalent:

(1) Aclar No. 33C film (Allied Chemical Corp).

(2) Pressure-sensitive tape RB0195-002 (Rocketdyne).

(3) Mass-spectrometer leak detector with a sensitivity capable of measuring 1×10^{-4} scc/sec.

(4) USON 500 helium leak detector (may be used for preliminary leak detection).

b. Remove protective closure from oxidizer turbopump primary seal drain line. If MD301 or MD302 change is incorporated, remove closure from stage overboard line.

c. Bag flange using Aclar No. 33C plastic film, and seal with pressure-sensitive tape RB0195-002 (Rocketdyne) as shown in figure 3-40A. Verify that 6 drain holes on downstream side of inlet duct flange (figure 3-40A) are sealed with pressure-sensitive tape RB0195-002 (Rocketdyne). (Fuel inlet ducts may not contain drain holes.)

CAUTION

Engines must be restrained to prevent gimbaling before ducts are pressurized.

- Pressurizing the inlet ducts with the MFV or MOV open can cause damage to the engine oxidizer or fuel flowmeters by dry-spinning.

d. Make sure MFV or MOV (as applicable for duct being pressurized) is closed. Using helium that meets requirements of section II, slowly pressurize inlet duct to 30 ±5 psig (normal stage propellant tank pressure capability above 10 psig is acceptable), and record pressure used.

e. Search torsional bellows flange joint for leakage as follows:

(1) Puncture plastic bag, insert probe of detection device, and search accessible area of flange joint for leakage, remove probe and seal plastic bag. Repeat procedure as required to search entire circumference of flange, and record whether excessive leakage is detected. Leakage measured at the probe must not exceed 1×10^{-4} scc/sec. If excessive leakage is detected perform substeps 2 through 5.

(2) If excessive leakage is detected, place a second bag of Aclar No. 33C plastic film over existing bag and seal with pressure-sensitive tape RB0195-002 (Rocketdyne) as shown in figure 3-40A.

(3) Using gaseous nitrogen (refer to section II), purge area between bags to clear any helium vapors from between bags. Maintain purge until just before rechecking flange area for leakage.

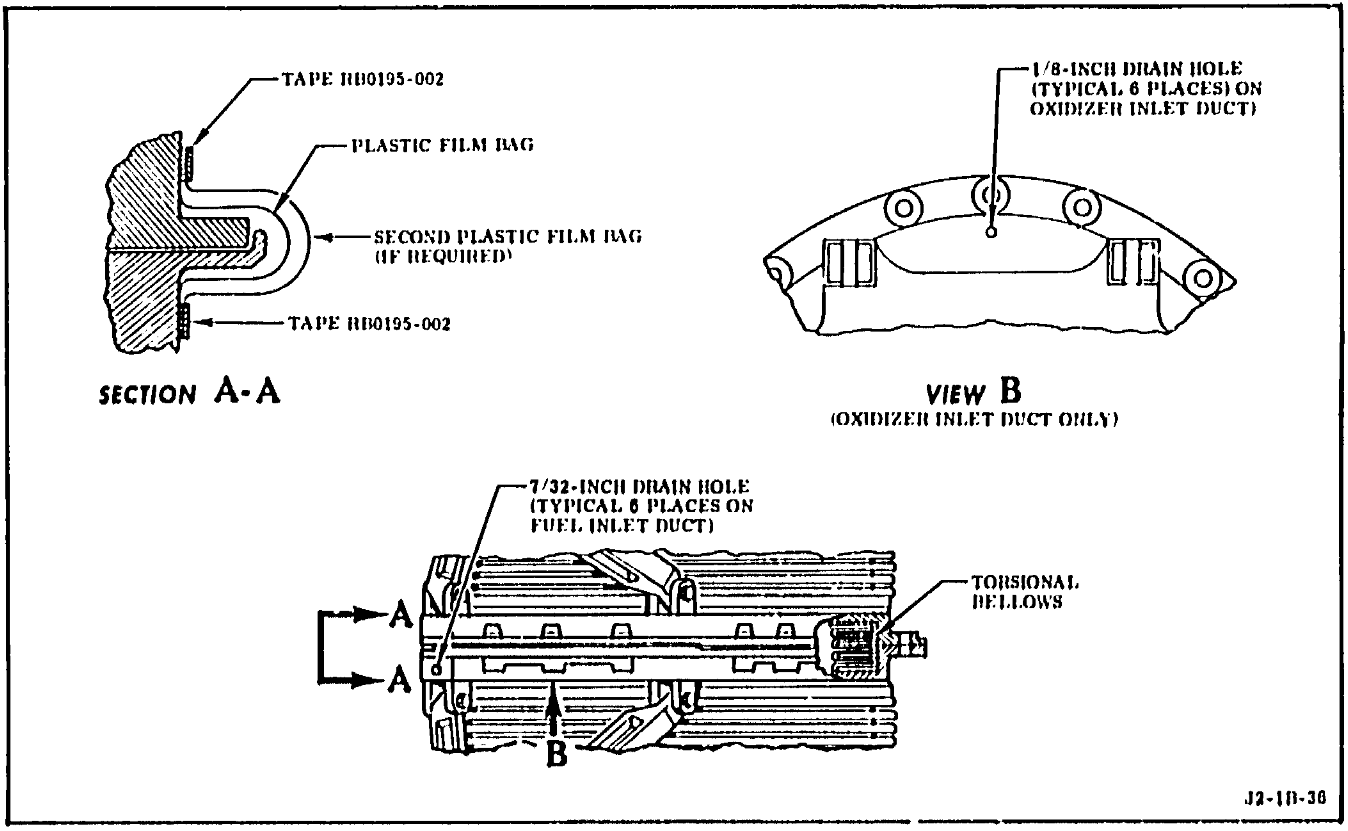


Figure 3-49A. Bagging Inlet Duct Center Flange for Torsional Bellows Leak Test

(4) Shut off purge and repeat search of flange joint for leakage.

(5) If leakage is detected using equipment other than a mass-spectrometer, steps d and e must be repeated using the mass-spectrometer to verify leakage.

f. Depressurize inlet duct before proceeding to next step.

g. If leakage in step e exceeded 1 x 10^{-4}, replace duct as outlined in R-3825-3.

h. Remove plastic bag and tape from flange joint, except do not remove tape from drain holes on downstream side of inlet duct flange joint.

i. Reinstall protective closure on oxidizer turbopump primary seal drain line. If MD301 or MD302 change is incorporated, reinstall closure on stage overboard line.

j. Install protective covers on flange joint, as outlined in R-3825-3, immediately after completion of leak check.

3.3.26 TESTING PURGE SYSTEM. Refer to section II for engine checkout constraints before performing this test.

a. Remove protective closures from the following:

(1) Oxidizer turbine seal drain line exit.

(2) Fuel turbine seal drain line exit.

(3) Thrust chamber exit. (Or open one desiccant access opening on closure.)

(4) Fuel turbopump primary seal drain line (stage overboard line).

(5) On engines incorporating MD301, MD302, MD322, or MD323 change, oxidizer turbopump primary seal drain line (stage overboard line).

b. Remove plug and seal from boss between fuel turbopump and fuel turbopump primary seal drain check valve.

c. Install exhaust system test plate (paragraph 3.3.3).

Operation	Result
d. Verify that adapter 9022823 installed on torque access of fuel turbine exhaust duct is vented to atmosphere; then apply 67-115 psig helium through purge manifold system pneumatic supply line.	Purge system is pressurized to 67-115 psig.

e. Using a pneumatic flowtester with an accumulator, measure and record flow at the following locations:

Operation	Result
(1) Oxidizer turbine seal drain. Record as oxidizer turbine seal drain purge flow.	Minimum allowable flow is 2,400 scim.
(2) Fuel turbine seal drain purge drain. Record as fuel turbine seal drain purge flow.	Minimum allowable flow is 2,400 xcim.
(3) Fitting between fuel turbopump and fuel turbopump primary seal drain check valve. Record as fuel turbopump primary seal flow.	Minimum allowable flow is 200 scim.
(4) Fitting on test adapter 9022823 installed on torque access of fuel turbine exhaust duct. Record as GG fuel purge flow.	Minimum allowable flow is 2,400 scim.
f. Decrease pressure to zero.	Purge system depressurizes.

g. If minimum flowrates specified in step e were not obtained, perform steps h through j. If specified flowrates were obtained, proceed to step k.

h. On engines incorporating MD234 change, remove bolts and washers that secure drain line to STDV and remove seal. Install test plate 9025399 from test plate kit 9025400 between line flange and valve drain port. Torque bolts to 40-45 in-lb.

i. On engines not incorporating MD234 change, remove bolts and washers that secure STDV drain line to thrust chamber exhaust manifold. Install leak test kit EWR325310 between line flange and thrust chamber exhaust manifold. Torque nuts to 41-45 in-lb.

j. Make sure stage helium supply pressure level of 67-115 psig is available at engine customer connect panel; then repeat steps d and e.

k. Reinstall plug and seal in boss between fuel turbopump and fuel turbopump primary seal drain check valve. Torque plug to 65-70 in-lb.

l. Apply 67-115 psig to purge system through purge manifold system pneumatic supply line.

Operation	Result
m. Leak-test plug in boss between fuel turbopump and fuel turbopump primary seal drain check valve.	Leakage is not allowable.
n. Leak-test the 4 purge lines from customer connect interface to the following:	Leakage is not allowable.

(1) Oxidizer turbopump.

(2) Fuel turbopump (2 lines).

(3) GG.

o. Decrease pneumatic pressure to zero.

p. On engines not incorporating MD234 change, if STDV drain line was disconnected, perform step q, then proceed to step ab.

q. Remove bolts and washers that secure STDV drain line to thrust chamber exhaust manifold, and remove test plate. Install new seal, and connect drain line to thrust chamber exhaust manifold with bolts and washers. Torque bolts to 68-73 in-lb.

r. On engines incorporating MD234 change, if STDV drain line is disconnected, perform steps s through aa. If STDV drain line is not disconnected, proceed to step ab.

NOTE

Steps s through aa leak-test the STDV drain line connection on engines incorporating MD234 change. On engines not incorporating MD234 change, the drain line connection cannot be leak tested.

s. Remove bolts and washers that secure STDV drain line to STDV, and remove test plate. Install new seal and connect drain line to STDV. Torque bolts to 42-45 in-lb, and safetywire.

t. Connect a pneumatic monitoring system incorporating a bleed valve and capable of measuring 30 ±1 psig to test adapter 9022823 installed on fuel turbopump torque access. Close bleed valve.

u. Install test adapter 9024523 from adapter kit 9024496 on exit end of fuel turbine seal drain line (at thrust chamber exit).

v. Connect a regulated helium (refer to section II) source capable of supplying 30 ±1 psig to test adapter 9024523.

w. Apply helium pressure to fuel turbine seal drain line until monitor gage at torque access of fuel turbopump indicates 30 ±1 psi.

Operation	Result
x. Leak-test drain line flange at STDV (G32).	Leakage is not allowable.

y. Decrease helium supply pressure to zero, and open bleed valve on monitor system connected to torque access of fuel turbopump.

z. Make sure monitor gage indicates zero; then disconnect monitor system from test adapter 9022823.

aa. Remove test adapter 0024523 from exit end of fuel turbine seal drain line, and install protective closure on line.

ab. Remove exhaust system test plate (paragraph 3.3.4).

NOTE

Steps ac through am are applicable only when testing an engine at stage static-test sites. When testing an engine at KSC, proceed to step an.

ac. Energize helium and mainstage control valves.

WARNING

Failure to observe the safety requirements of step ad can result in injury to personnel.

ad. Direct all personnel to stand behind adequate safety barriers or at a safe distance from engine when performing steps ae through ag.

ae. Apply 400-1,600 psig helium pressure to helium tank.

af. Deenergize mainstage control valve.

ag. Decrease helium pressure entering helium tank to 225-250 psig, and wait one minute for system pressure to bleed down to 225-250 psig.

Operation	Result
ah. Using pneumatic flowtester, leak-test OTBV opening control port.	Leakage is not allowable.

ai. Energize ignition-phase and mainstage control valves.

Operation	Result
aj. Using pneumatic flowtester, leak-test OTBV closing control port flange.	Leakage is not allowable.

ak. Deenergize ignition-phase and mainstage control valves.

al. Decrease pressure to helium tank to zero.

am. Allow all pressure to vent from helium tank. Deenergize helium control valve.

NOTE

Steps an through au are applicable to KSC only.

an. Energize helium, ignition-phase, and mainstage control valves.

ao. Apply 600-1,600 psig helium pressure to helium tank.

Operation	Result
ap. Remove threaded plug from leak detection port and, using pneumatic flowtester, leak-test OTBV closing control port flange (P21).	Leakage is not allowable.

aq. Deenergize mainstage and ignition-phase control valves.

Operation	Result
ar. Remove threaded plug from leak detection port and, using pneumatic flowtester, leak-test OTBV opening control port flange (P22).	Leakage is not allowable.

as. Decrease pressure to helium tank to zero.

at. Allow all pressure to vent from helium tank. Deenergize helium control valve.

au. Reinstall threaded plugs in leak detection ports and torque to 22-28 in-lb. (Safetywire plugs after prelaunch tests.)

av. Install protective closures on all open purge exits.

3.3.27 <u>TESTING CHECK VALVES AND PUMP SEALS.</u> Refer to section II for engine checkout constraints before performing this test.

3.3.27.1 Reverse-Flow-Testing Fuel Turbine Seal Purge Check Valve.

a. Install test adapter 9024523 from adapter kit 9024490 on exit end of fuel turbine seal drain line.

b. On engines incorporating MD234 change, remove bolts and washers that secure drain line to STDV and remove seal. Install test plate 9025399 from test plate kit 9025400-11 between line flange and valve drain port. Torque bolts to 41-45 in-lb.

c. Connect a regulated supply of helium (refer to section II) capable of supplying 30 ±1 psig to adapter installed on fuel turbine seal drain line exit.

d. Apply 30 ±1 psig to fuel turbine seal drain line.

Operation	Result
e. Using pneumatic flowtester, measure leakage at purge manifold system supply line. Record as fuel turbine seal purge check valve reverse leakage.	Maximum allowable leakage is 100 scim.

NOTE

If the exhaust system test plates are installed and the GG and exhaust system is not vented to atmosphere, this value is actually a combination of the fuel turbine seal purge check valve reverse leakage and the GG fuel purge check valve reverse leakage. If the measured leakage is less than 100 scim, both check valves are acceptable. If the measured leakage is more than 100 scim, leakage must be isolated during GG and exhaust system test (paragraph 3.3.31).

f. Leak-test fuel turbine seal drain line.	Leakage is not allowable.

g. Decrease pneumatic pressure to zero.

h. Disconnect test hose from fuel turbine seal drain line exit.

3.3.27.2 Reverse-Flow-Testing Oxidizer Turbine Seal Purge Check Valve and Leak-Testing Oxidizer Turbopump Primary Seal Drain Line.

a. Install test adapter 9024523 from adapter kit 9024490 on oxidizer turbine seal drain line exit.

b. Connect a regulated supply of helium (refer to section II) capable of supplying 30 ±1 psig to adapter 9024523.

c. Remove protective closure from oxidizer turbopump intermediate seal purge check valve vent line exit.

d. Energize helium, ignition-phase, and mainstage control valves.

e. Slowly pressurize helium tank to 225-250 psig at stage static-test sites or to 600-1,600 psig at KSC.

f. Apply 30 ±1 psig to oxidizer turbine seal drain line.

Operation	Result
g. Using pneumatic flowtester, measure leakage at purge manifold system pneumatic supply line. Record as oxidizer turbine seal purge check-valve reverse leakage.	Maximum allowable leakage is 100 scim.
h. Leak-test oxidizer turbine seal drain line weld joints.	Leakage is not allowable.

i. Decrease pneumatic pressure to turbine seal drain line to zero.

j. Deenergize ignition-phase and mainstage control valves and decrease pneumatic pressure to helium tank to zero. After all pressure has vented from helium tank, deenergize helium control valve.

k. Disconnect helium supply from adapter 0024523.

l. Connect a regulated supply of helium (refer to section II) capable of supplying 30 ±1 psig to OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect, using test plate 0020222-11 from kit 9018843-11. Test plate is not required if helium is supplied from stage source.

m. If burst diaphragm is installed on oxidizer turbopump primary seal drain line, remove burst diaphragm. (Refer to R-3825-3.) Install plug AN806S16 in place of burst diaphragm on end of drain line. Torque plug to 290-300 in-lb.

n. Slip a plastic tube over oxidizer turbopump intermediate seal purge check valve vent line and route tube to direct gas flow away from immediate engine area.

o. Energize helium, ignition-phase, and mainstage control valves.

p. Slowly pressurize helium tank to 225-250 psig at stage static-test sites or to 600-1,600 psig at KSC.

q. Apply and maintain 30 ±1 psig to OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect line.

Operation	Result
r. Leak-test all joints and connections in oxidizer turbopump primary seal drain line.	Leakage is not allowable.
s. Using leak detector, leak-test braided section of OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect line.	Leakage is not allowable.
t. Leak-test connections of oxidizer turbopump primary seal cavity pressure line PO6 (L42) from turbopump to auxiliary FI package and to static-test transducer.	Leakage is not allowable.

u. Decrease pneumatic pressure to primary seal drain customer connect line to zero.

v. Deenergize ignition-phase and mainstage control valves, and decrease pneumatic pressure to helium tank to zero. After all pressure has vented from helium tank, deenergize helium control valve.

w. Remove plastic tube installed in step n, and remove test equipment from OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.

x. Remove plug AN806S16 (if installed) on end of oxidizer turbopump primary seal drain line. Reinstall burst diaphragm. (Refer to R-3825-3.)

y. Remove adapter from oxidizer turbine seal drain line. Install protective closures on drain lines.

3.3.27.3 Reverse-Flow-Testing Fuel Turbopump Primary Seal Drain Check Valve.

a. Install test plate 9020222-11 from test plate kit 9018843-11 on FUEL PUMP DRAIN customer connect. Torque bolts to 61-75 in-lb.

b. Remove plug and seal from boss between fuel turbopump and fuel turbopump primary seal drain check valve.

c. Connect a regulated supply of helium (refer to section II) capable of supplying 30 ±1 psig to FUEL PUMP DRAIN customer connect.

d. Apply 30 ±1 psig to FUEL PUMP DRAIN customer connect.

Operation	Result
e. Using pneumatic flowtester, measure leakage from boss between fuel turbopump and check valve. Record as fuel turbopump primary seal drain check-valve reverse leakage.	Maximum allowable leakage is 25 scim.

Operation	Result
f. Leak-test drain line from check valve to customer-connect interface.	Leakage is not allowable.
g. On engines incorporating MD320 change, leak-test line from fuel turbopump primary seal drain line to start tank emergency vent valve.	Leakage is not allowable.

h. Decrease pneumatic pressure to zero.

i. Disconnect pressure hose from test plate on FUEL PUMP DRAIN customer connect.

NOTE

If check valve testing is to be continued, steps j and k may be disregarded.

j. Reinstall plug and new seal in boss between fuel turbopump and fuel turbopump primary seal drain check valve. Torque plug to 65-70 in-lb.

k. Secure equipment (paragraph 3.3.27.7).

3.3.27.4 Reverse-Flow-Testing Fuel Turbopump Primary Seal Purge Check Valve and Leak-Testing Fuel Turbopump Secondary Seal.

a. Remove plug and seal from boss between fuel turbopump and fuel turbopump primary seal drain check valve. Install adapter assembly 9025420 from fuel turbopump leak and flow adapter kit 9025419. When installing adapter assembly, torque adapter 9025421 to 5 (+0, -1) in-lb, and torque elbow nut on adapter to 4 (+0, -1) in-lb.

b. Connect a regulated supply of helium (refer to section II) capable of supplying 30 ±1 psig to adapter 9025420.

c. Remove plug and seal from torque access of fuel turbine exhaust duct.

d. On engines not incorporating MD172 change, install torque wrench to adapter 9019861-11 from wrench kit 9016711-11, insert through torque access, and engage splines of turbine shaft and adapter.

e. On engines incorporating MD172 change, install torque wrench to adapter 19-9025816 from wrench kit 9016711-21, insert through torque access, and engage hex on turbine wheel.

f. Apply 30 ±1 psig to boss between fuel turbopump and fuel turbopump primary seal drain check valve.

Operation	Result
g. Using pneumatic flowtester, measure leakage from purge manifold system pneumatic supply line. Record as fuel turbopump primary seal purge check valve reverse leakage.	Maximum allowable leakage is 100 scim.
h. Using pneumatic flowtester to measure leakage from fuel turbine seal drain line, rotate turbine wheel counterclockwise (viewed from aft end of engine) a minimum of 5 complete revolutions to determine maximum leakage point. Continue to rotate turbine to position of maximum leakage, and record as fuel turbopump secondary seal leakage.	For allowable leakage limits see figure 3-47 for SIVB-stage installed engines and figures 3-48 and 3-49 for SII-stage installed engines.

i. Decrease pneumatic pressure to zero.

CAUTION

Joint connected in step j cannot be leak tested, therefore condition and security of joint (section II) must be inspected and inspection recorded by each of two persons.

j. Remove torque wrench and adapter, and install plug and new seal in fuel turbine torque access opening. Torque plug to 405-445 in-lb. Obtain verification of acceptable condition and security of joint (section II) by each of two persons.

NOTE

If check valve testing is to be continued, steps k and l may be disregarded.

k. Disconnect pressure hose from boss between fuel turbopump and fuel turbopump primary seal drain check valve, and reinstall plug and new seal in fitting. Torque plug to 65-70 in-lb.

l. Secure equipment (paragraph 3.3.27.7).

3.3.27.5 Flow-Testing Fuel Turbopump Primary Seal Drain Check Valve.

a. Remove plug and seal from boss between fuel turbopump and fuel turbopump primary seal drain check valve. Install adapter assembly 9025420 from fuel turbopump leak-and-flow adapter kit 9025419. When installing adapter assembly, torque adapter 9025421 to 5 (+0, -1) in-lb, and torque elbow nut on adapter to 4 (+0, -1) in-lb.

b. Connect a tee fitting to adapter assembly 9025420, and install a monitor gage capable of monitoring 60 ±2 psi to tee fitting.

c. Connect a regulated supply of helium (refer to section II) capable of supplying 30 ±1 psig and 60 ±2 psig to tee fitting on adapter assembly 9025420.

d. Apply helium pressure to adapter assembly 9025420 until monitor gage indicates 30 ±1 psi.

Operation	Result
e. Using pneumatic flowtester, measure leakage at FUEL PUMP DRAIN customer connect. Record as fuel turbopump primary seal drain check valve forward leakage.	Maximum allowable leakage is 30 scim.
f. Increase helium pressure until monitor gage indicates 60 ±2 psi.	Fuel turbopump primary seal drain check valve unseats.
g. Using pneumatic flowtester, measure flow at FUEL PUMP DRAIN customer connect. Record as fuel turbopump primary seal drain check valve flow.	Minimum allowable flow is 2,420 scim.
h. Decrease pneumatic pressure to zero.	Fuel turbopump depressurizes.

i. If flow of 2,420 scim or more was not obtained in step g, perform steps j through n. If flow was 2,420 scim or greater, proceed to step o.

j. Verify that fuel turbopump secondary seal leakage is acceptable (paragraph 3.3.27.4).

k. Make sure engine is stabilized by one of the following methods:

(1) Engine gimbal actuator connected and locked mechanically or hydraulically.

(2) Stiff arms installed.

(3) Engine Restrainer Assembly G4066 installed and attached to test stand outriggers.

l. Verify that fuel chilldown return system is closed; then slowly pressurize engine fuel feed system to 30 ±5 psig.

m. Repeat steps f through h. When repeating test, monitor fuel feed system pressure and vent as required to maintain 30 ±5 psig. Fuel turbopump primary seal drain check valve flow must be 2,420 scim or greater.

n. Decrease fuel feed system pressure to zero.

o. Disconnect test equipment from boss between fuel turbopump and fuel turbopump primary seal drain check valve. Reinstall plug and new seal in fitting. Torque plug to 65-70 in-lb.

NOTE

If check valve testing is to be continued, steps k and l may be disregarded.

k. Disconnect pressure hose from boss between fuel turbopump and fuel turbopump primary seal drain check valve, and reinstall plug and new seal in fitting. Torque plug to 65-70 in-lb.

l. Secure equipment (paragraph 3.3.27.7).

3.3.27.5 Flow-Testing Fuel Turbopump Primary Seal Drain Check Valve.

a. Remove plug and seal from boss between fuel turbopump and fuel turbopump primary seal drain check valve. Install adapter assembly 9025420 from fuel turbopump leak-and-flow adapter kit 9025419. When installing adapter assembly, torque adapter 9025421 to 5 (+0, -1) in-lb, and torque elbow nut on adapter to 4 (+0, -1) in-lb.

b. Connect a tee fitting to adapter assembly 9025420, and install a monitor gage capable of monitoring 60 ±2 psi to tee fitting.

c. Connect a regulated supply of helium (refer to section II) capable of supplying 30 ±1 psig and 60 ±2 psig to tee fitting on adapter assembly 9025420.

d. Apply helium pressure to adapter assembly 9025420 until monitor gage indicates 30 ±1 psi.

Operation	Result
e. Using pneumatic flowtester, measure leakage at FUEL PUMP DRAIN customer connect. Record as fuel turbopump primary seal drain check valve forward leakage.	Maximum allowable leakage is 30 scim.
f. Increase helium pressure until monitor gage indicates 60 ±2 psi.	Fuel turbopump primary seal drain check valve unseats.
g. Using pneumatic flowtester, measure flow at FUEL PUMP DRAIN customer connect. Record as fuel turbopump primary seal drain check valve flow.	Minimum allowable flow is 2,420 scim.
h. Decrease pneumatic pressure to zero.	Fuel turbopump depressurizes.

i. If flow of 2,420 scim or more was not obtained in step g, perform steps j through n. If flow was 2,420 scim or greater, proceed to step o.

j. Verify that fuel turbopump secondary seal leakage is acceptable (paragraph 3.3.27.4).

k. Make sure engine is stabilized by one of the following methods:

(1) Engine gimbal actuator connected and locked mechanically or hydraulically.

(2) Stiff arms installed.

(3) Engine Restrainer Assembly G4066 installed and attached to test stand outriggers.

l. Verify that fuel chilldown return system is closed; then slowly pressurize engine fuel feed system to 30 ±5 psig.

m. Repeat steps f through h. When repeating test, monitor fuel feed system pressure and vent as required to maintain 30 ±5 psig. Fuel turbopump primary seal drain check valve flow must be 2,420 scim or greater.

n. Decrease fuel feed system pressure to zero.

o. Disconnect test equipment from boss between fuel turbopump and fuel turbopump primary seal drain check valve. Reinstall plug and new seal in fitting. Torque plug to 65-70 in-lb.

3.3.27.6 Reverse-Leak-Testing Gas Generator Oxidizer Purge Check Valve.

a. Disconnect line, and remove seal downstream of GG oxidizer purge check valve.

b. Install test plate 9025379 from test plate kit 9024497 on line downstream of GG oxidizer purge check valve. Torque nuts to 24-30 in-lb.

bA. On engines incorporating MD383 or MD384 change, remove plug from oxidizer injector pressure tap CN1.

c. Connect a regulated supply of helium (refer to section II) capable of supplying 30 ±5 psig to test plate 9025379.

d. Apply 30 ±5 psig to line downstream of GG oxidizer purge check valve. Apply test pressure for a minimum of 5 minutes.

Operation	Result
e. Using pneumatic flowtester, measure leakage at purge control valve vent line exit or, on engines incorporating MD383 or MD384 change, at pressure tap CN1. Record actual value as GG oxidizer purge check valve reverse leakage.	Maximum allowable leakage is 15 scim.

f. Decrease pneumatic pressure to zero.

g. Disconnect test hose from test plate 9025379.

h. Remove test plate from GG oxidizer purge line.

i. Install new seal, and connect GG oxidizer purge line. Torque bolts to 19-21 in-lb.

j. Inspect the 4 bolts securing flange downstream of GG oxidizer purge check valve for proper length. A minimum of one full thread must protrude beyond top of nut.

k. On engines incorporating MD383 or MD384 change, install new seal and reinstall plug in pressure tap CN1. Torque plug to 66-73 in-lb and safetywire.

3.3.27.6A Reverse-Leak-Testing Redundant Purge Check Valve (Engines Incorporating MD383 or MD384 Change).

a. The following test equipment is required:

(1) Pneumatic Flow Tester G3104.

(2) Test plate kit 9024497.

(3) Shutoff plug kit 9020784-11.

b. Remove valve assembly 9591-59061 from oxidizer dome purge shutoff plug 9025402 (part of shutoff plug kit 9020784-11.

c. Remove plug from oxidizer injector pressure tap CN1 and install shutoff plug 9025402 in pressure tap. Torque plug fingertight.

d. Disconnect line at in-line flange and remove seal downstream of GG oxidizer purge check valve.

e. Install test plate 9025379 from test plate kit 9024497 on line flange downstream of GG oxidizer purge check valve. Torque nuts to 24-30 in-lb. (Pressure cap must be installed on test plate kit.)

f. Connect a regulated supply of helium (refer to section II) capable of supplying 30 ±5 psig to shutoff plug installed in pressure tap CN1. Torque fitting to shutoff plug fingertight.

g. Remove protective closure from purge control valve vent line at thrust chamber exit.

h. Apply 30 ±5 psig to pressure tap CN1.

Operation	Result
i. Using pneumatic flowtester, measure leakage at purge control valve vent line. Record as redundant purge check valve reverse leakage.	Maximum allowable leakage is 30 scim.

j. Reduce helium supply to zero and vent system.

k. Disconnect helium supply from pressure tap CN1 and remove shutoff plug.

l. Install new seal and reinstall plug in oxidizer injector pressure tap CN1. Torque plug to 66-73 in-lb and safetywire.

m. Remove test plate from GG oxidizer purge line flange.

n. Install new seal, and reconnect GG oxidizer purge line. Torque bolts to 19-21 in-lb.

o. Install protective closure on purge control valve vent line.

p. Reinstall valve assembly 9591-59061 in oxidizer dome purge shutoff plug kit (removed in step b). Torque valve assembly fingertight.

3.3.27.7 Securing After Test.

a. On engines incorporating MD234 change, remove bolts and washers that secure STDV drain line to valve, and remove test plate. Install new seal, and connect drain line to STDV with bolts and washers. Torque bolts to 42-45 in-lb, and safetywire.

b. Remove threaded plugs from leak detection ports as required during system test. (See figure 3-32.)

c. Apply 97-115 psig to purge system through purge manifold system pneumatic supply line.

Operation	Result
d. Leak-test plug in boss between fuel turbopump and fuel turbopump primary seal drain check valve.	Leakage is not allowable.

e. Decrease pneumatic pressure to purge system to zero.

NOTE

Steps f through n leak-test the purge control valve outlet port flange and GG oxidizer purge line flange. These steps may be disregarded if a pneumatic control system test (paragraph 3.3.29) is to be performed.

f. On engines incorporating MD301, MD302, MD322, or MD323 change, make sure stage overboard line from oxidizer turbopump primary seal drain line is not capped.

g. Energize helium and mainstage control valves.

WARNING

Failure to observe the safety requirements of step h can result in injury to personnel.

h. When performing test at stage static-test sites, direct all personnel to stand behind adequate safety barriers or at a safe distance from engine when performing steps i through k.

i. Apply 600-1,600 psig helium pressure to helium tank.

j. Deenergize mainstage control valve.

k. When performing test at stage static-test sites, decrease helium pressure entering helium tank to 225-250 psig and wait one minute for system pressure to bleed down to 225-250 psig.

Operation	Result
l. Using pneumatic flowtester, leak-test gas generator oxidizer purge line flange (P27).	Leakage is not allowable.

Operation	Result
m. Using pneumatic flowtester, leak-test purge control valve pneumatic outlet flange (P18).	Leakage is not allowable.

n. Decrease pressure to helium tank to zero. Allow all pressure to vent from helium tank; then deenergize helium control valve.

NOTE

Steps o through x leak-test the STDV drain line on engines incorporating MD234 change. These steps may be disregarded if a GG and exhaust system test (paragraph 3.3.31) is to be performed.

o. Install exhaust system test plates (paragraph 3.3.3).

p. Connect a pneumatic monitoring system incorporating a bleed valve and capable of measuring 30 ±1 psig to test adapter 9022823 installed on fuel turbopump torque access.

q. Install test adapter 9024523 from adapter kit 9024496 on exit end of fuel turbine seal drain line (at thrust chamber exit). Torque hose clamps to 12-15 in-lb.

r. Connect a regulated helium source capable of supplying 30 ±1 psig to test adapter 9024523.

s. Apply helium pressure to fuel turbine seal drain line until monitor gage at torque access of fuel turbopump indicates 30 ±1 psi.

t. Leak-test drain line flange at STDV (G32).	Leakage is not allowable.

u. Decrease helium supply pressure to zero.

v. Open bleed valve on monitor system connected to fuel turbopump torque access. Make sure monitor gage indicates zero; then disconnect monitor system from test adapter 9022823.

w. Remove test adapter 9024523 from exit end of fuel turbine seal drain line, and install protective closure on line.

x. Remove exhaust system test plates (paragraph 3.3.4).

y. Remove test plate 9020222-11 from FUEL PUMP DRAIN customer connect.

z. Reinstall leak detector plugs, and torque to 22-28 in-lb. (Safetywire plugs after prelaunch leak tests.)

3.3.28 LEAK-TESTING MAIN OXIDIZER VALVE SEQUENCE CONTROL VALVE LIP SEAL. Refer to section II for checkout constraints before performing this test.

a. In accordance with site safety standards, position Pneumatic Flow Tester G3104 far enough from engine to protect personnel from danger.

b. Remove vent port check valve from vent port of GG control valve.

c. Install elbow AN776-4, bolt AN775-4, and 2 seals AN901-4S in vent port of GG control valve. Attach a short length of 1/4-inch OD CRES tubing to side outlet of elbow to permit connection of Tygon tubing.

d. Obtain a sufficient length of 1/4-inch ID Tygon tubing to reach from 1/4-inch CRES tubing installed in step c to flowtester.

e. If Tygon tubing exceeds 96 inches, apply a 10-15 psig helium purge to Tygon tubing for approximately one minute.

f. Connect Tygon tubing to elbow installed in vent port of GG control valve and to flowtester.

WARNING

Failure to observe safety requirements of step g can result in injury to personnel.

g. Direct all personnel to stand behind adequate safety barriers or at a safe distance from engine.

h. Energize helium control valve.

i. Slowly pressurize engine helium tank to 600 psig minimum.

Operation	Result
j. Energize ignition-phase control valve and allow flowmeter to stabilize; then read and record flow from vent port of GG control valve.	Maximum allowable leakage is 5 scim.

NOTE

The value recorded in step j is the combined MOV sequence seal and OTBV piston lip seal (opening pressure) leakage.

k. If measured leakage does not exceed 5 scim, proceed to step p. If leakage exceeds 5 scim, continue with test.

l. Deenergize ignition-phase control valve.

Operation	Result
m. Allow flowmeter to stabilize; then read flow from vent port of GG control valve. Record leakage as OTBV piston lip seal leakage (opening pressure).	Maximum allowable leakage is 10 scim.
n. Subtract flow recorded in step m from flow recorded in step j. Record this value as MOV sequence seal leakage.	Maximum allowable leakage is 5 scim.

o. If maximum allowable flowrate specified in step m or n is exceeded, contact Engine Contractor, Field Engineering for disposition.

p. Deenergize ignition-phase control valve if not previously deenergized.

q. Shut off all supply pressure, and allow helium tank pressure to decay to zero. After all pressure has vented from the helium tank, deenergize helium control valve.

r. Disconnect flowtester, remove elbow, bolt, and seals installed in step c, and install vent port check valve. (Refer to R-3825-3.)

3.3.29 LEAK-TESTING PNEUMATIC CONTROL SYSTEM. Refer to section II for checkout constraints before performing this test. Refer to paragraph 3.3.2 for seal leak-test points. If electrical power cannot be supplied through the interface, solenoid remote-control box 99-9019901 may be used to energize the engine control valves.

a. Disconnect pneumatic inlet line, and remove seal from inlet port of purge control valve. Install test plate 9025300 from test plate kit 9025400-11 between line and valve inlet port. Torque to 41-45 in-lb.

b. On engines not incorporating MD301, MD302, MD322, or MD323 change, disconnect overboard vent line from purge control valve, and remove seal.

c. Remove vent port relief valve from boss in MFV closing control line. Using packing MS28778-4, install vent adapter assembly 9025423, or a vent valve, in boss. Torque to 40-65 in-lb. Make sure vent adapter or vent valve is closed.

NOTE

The vent adapter or vent valve is used to eliminate the flow of helium to prevent depletion of the facility and engine helium tank helium supply.

d. Remove protective covers from the following:

(1) Thrust chamber exit (or one-desiccant access cover from exit closure).

(2) Oxidizer turbopump primary seal drain line. (Stage overboard drain line on engines incorporating MD301, MD302, MD322, or MD323 change.)

(3) Oxidizer turbopump intermediate seal purge check-valve vent.

CAUTION

On engines incorporating MD366 or MD371 change, the tube (which looks like a plug) must not be removed from the seal at the MRCV pneumatic inlet port.

e. Using tool T-6044445, remove all brass plugs from leak detection ports of pneumatic control system before start of test. (See figure 3-32.) Removal of brass plugs is not required if engine helium supply system pressure-decay test and pneumatic system helium usage test (paragraphs 3.3.30 and 3.3.38) have been accomplished successfully.

eA. On engines incorporating MD366 or MD371 change, remove plastic cap from MRCV pneumatic inlet leak-detection port.

f. Energize helium control valve.

g. Slowly pressurize helium tank to 225-250 psig at stage static-test sites or to 600-1,600 psig at KSC.

Operation	Result
h. Leak-test from helium tank customer connect to helium tank, including the following seal leak-test ports:	Leakage is not allowable.

(1) Engine/stage interface.

(2) Helium fill-check valve to helium tank (P32).

(3) Helium tank temperature transducer (P28).

Operation	Result
i. Leak-test the following connections from helium tank to helium regulator assembly (pneumatic control package).	Leakage is not allowable.

(1) High-pressure line to pneumatic control package (15).

(2) Helium tank pressure line NN1 to primary FI package. (On engines incorporating MD269, MD282, MD296, MD313, or MD315 change, line to auxiliary FI package).

Operation	Result
j. On engines not incorporating MD150, MD280, or MD281 change, leak-test connections of the following stage static instrumentation lines:	Leakage is not allowable.

(1) Helium tank pressure line from tee to line NN1 to static-test transducer.

(2) Pneumatic package instrumentation line NN2 (P14) to static-test transducer.

Operation	Result
k. Using pneumatic flowtester, leak-test the following seal test ports:	Leakage is not allowable.

(1) Pneumatic package instrumentation port NN2 (P14).

(2) Helium regulator assembly bleed valve control and pneumatic accumulator line outlet flange (17).

(3) Pneumatic accumulator inlet line to primary F1 package (P20).

(4) OTBV opening control line (P22).

(5) MOV closing control line (P3).

(6) MFV closing control line (P26).

(7) Oxidizer bleed valve closing control line (P1).

(8) Fuel bleed valve closing control line (P35).

(9) ASI valve closing control line (P12).

(10) Ignition-phase control manifold to ignition-phase control valve (normally open port) (P16).

(11) Mainstage control manifold to mainstage control valve (normally open port) (P13).

(12) On engines incorporating MD366 or MD371 change, MRCV pneumatic inlet port (P38). (Reinstall plastic cap on tube at leak-detection port.)

(13) On engines incorporating MD172 or MD214 change, MOV thermal compensating orifice plate (P37).

Operation	Result
l. Leak-test the following normally open lines of pneumatic control system:	Leakage is not allowable.

(1) From pneumatic package instrumentation port NN2 to auxiliary FI package.

(2) From pneumatic package instrumentation port NN2 to oxidizer turbopump intermediate seal purge connection, including check valve.

(3) From oxidizer turbopump primary seal cavity pressure port PO6 to auxiliary FI package.

(4) From helium regulator assembly to pneumatic accumulator inlet flange.

(5) From tee in pneumatic accumulator fill line to purge control valve inlet, oxidizer bleed valve control port and fuel bleed valve control port.

(6) On engines incorporating MD366 or MD371 change, from tee in oxidizer turbopump intermediate seal purge line to MRCV pneumatic inlet port.

Operation	Result
m. Leak-test lines from mainstage control valve (normally open port) to the following:	Leakage is not allowable.

(1) Purge control valve control (actuation) port.

(2) MOV closing control port flange.

(3) OTBV opening control port flange.

Operation	Result
n. Leak-test from ignition-phase control valve (normally open port) to the following ports:	Leakage is not allowable.

(1) Fast-shutdown valve control (actuation) port.

(2) MFV closing control port.

(3) ASI valve closing control port.

Operation	Result
nA. On engines incorporating MD366 or MD371 change, energize MRCV low EMR command.	MRCV must move to low EMR (MRCV open).
nB. On engines incorporating MD366 or MD371 change, using pneumatic flowtester, measure leakage at MRCV vent port (port A). Record as MRCV actuator piston lip seal leakage.	Maximum allowable leakage is 20 scim.
nC. On engines incorporating MD366 or MD371 change, deenergize MRCV low EMR command.	MRCV must move to high EMR (MRCV closed).

nD. On engines incorporating MD366 or MD371 change, reinstall vent port check valve in MRCV (port A). (Refer to R-3825-3.)

o. Remove vent port check valve from fast-shutdown valve (located on end of valve opposite control port).

Operation	Result
p. Using pneumatic flowtester, measure leakage at vent port. Record as fast-shutdown valve diaphragm leakage.	Maximum allowable leakage is 3 scim.

q. If fast-shutdown valve diaphragm leakage exceeds 3 scim, perform steps r through v. If leakage rate is 3 scim or less, proceed to step w.

r. Remove vent port check valve from GG control valve adjustment plate.

Operation	Result
s. Energize engine mainstage control valve.	Mainstage control indication is obtained.

t. Repeat step p. If leakage rate is 3 scim or less, fast-shutdown valve diaphragm leakage rate is acceptable.

Operation	Result
u. Deenergize mainstage control valve.	Mainstage control indication is lost.

v. Install vent port check valve in GG. (Refer to R-3825-3.)

w. Install vent port check valve in fast-shutdown valve. Tighten valve fingertight.

Operation	Result
x. Remove vent port check valve from purge control valve and, using pneumatic flowtester, measure diaphragm leakage from purge control valve at vent port.	Maximum allowable leakage is 3 scim.

y. Install vent port check valve in purge control valve. (Refer to R-3825-3.)

CAUTION

Opening the MFV or the MOV with the stage propellant tanks pressurized and the pre-valves open or with more than 5 psig in the inlet ducts with the pre-valves closed can damage the engine oxidizer and fuel flowmeters by dry-spinning in excess of 60 seconds.

z. Verify that pressure in the propellant inlet ducts is not greater than 5 psig and that the stage pre-valves are closed.

Operation	Result
aa. Energize engine ignition-phase control valve.	Ignition-phase control indication is obtained.
ab. Using pneumatic flowtester, leak-test the following seal test ports:	Leakage is not allowable.

(1) Ignition-phase control manifold to pneumatic control package (normally closed port) (P16).

(2) MFV opening control port (P23).

(3) MFV sequence valve outlet port (P25).

(4) ASI valve opening control port (P11).

(5) MOV sequence valve inlet port (P6).

(6) MFV sequence valve inlet port (P24).

(7) STDV closing control port (P31).

(8) STDV control valve to adapter (normally open port) (P32).

Operation	Result
ac. Leak-test control lines from pneumatic control package to the following test ports:	Leakage is not allowable.

(1) ASI valve opening control port (P11).

(2) MOV sequence valve inlet port (P6).

(3) MFV opening control port (P23).

(4) MFV sequence valve inlet port (P24).

(5) From MFV sequence valve outlet port (P25) to STDV.

ad. Slip a plastic tube over oxidizer turbopump intermediate seal purge check valve vent line, and route tube to direct gas flow away from immediate engine area.

Operation	Result
ae. Using leak detector, leak-test braided section of pneumatic accumulator hose.	Leakage is not allowable.

af. Remove plastic tube installed in step ad.

ag. Make sure engine start tank is not pressurized.

Operation	Result
ah. Energize engine STDV control valve.	STDV control indication is obtained. Leakage is not allowable.

ai. Leak-test line from STDV control valve to STDV (opening port) (P30) and blanked off control port on side of STDV.

Operation	Result
aj. Using pneumatic flowtester, leak-test at the following seal test ports:	Leakage is not allowable.

(1) STDV control valve to adapter (normally closed port) (P32).

(2) STDV opening control line (P30) to STDV.

Operation	Result
ak. Deenergize STDV control valve.	STDV control indication is lost.
al. Energize engine mainstage control valve.	Mainstage control indication is obtained.
am. Using pneumatic flowtester, leak-test the following seal test ports:	Leakage is not allowable.

(1) Mainstage control manifold to pneumatic control package (normally closed port) (P13).

(2) MOV first-stage actuator inlet (opening control port) (P5).

(3) MOV second-stage actuator inlet (opening control port) (P2).

(4) MOV sequence valve outlet adapter to GG and fast-shutdown valve control line (P8).

(5) Fast-shutdown valve inlet port (P33).

(6) GG opening control port (P34).

(7) MOV to sequence valve seal (P4) (MOV sequence valve body).

(8) MOV sequence valve connection to outlet adapter and MOV sequence valve outlet adapter to OTBV closing control line (P7) (P9).

(9) OTBV closing control port (P21).

Operation	Result
an. Leak-test control lines from pneumatic control package to MOV opening control ports (first- and second-stage inlet ports).	Leakage is not allowable.
ao. Leak-test the following control lines:	Leakage is not allowable.

(1) MOV sequence valve to OTBV closing control port.

(2) MOV sequence valve to fast-shutdown valve.

(3) Fast-shutdown valve to GG.

Operation	Result
ap. Remove vent port check valve from fast-shutdown valve (located on end of valve opposite control port) and, using pneumatic flowtester, measure leakage from vent port. Record fast-shutdown valve seat leakage.	Maximum allowable leakage is 10 scim.

aq. Install vent port check valve on fast-shutdown valve. (Refer to R-3825-3.)

ar. Deenergize engine mainstage control valve.	Mainstage control indication is lost.
as. Deenergize engine ignition-phase control valve.	Ignition-phase control indication is lost.

at. Shut off pressure to engine helium tank. Open hand valve or vent adapter 0025423 in boss in MFV closing control line to vent pressure from control system. After all pressure is vented, close hand valve.

au. Deenergize engine helium control valve.	Helium control indication is lost.

av. Remove test plate kit 0025400-11 from between inlet port of purge control valve and inlet line. Install new seal, and connect line to inlet port of purge control valve. Torque bolts to 41-45 in-lb.

aw. Energize engine helium and mainstage control valves.

ax. Slowly pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,600 psig at KSC.

ay. Using pneumatic flowtester, measure leakage from purge control valve vent line exit. Record actual value as purge control valve seat leakage.	Maximum allowable leakage is 10 scim.
az. Leak-test purge control valve pneumatic inlet port flange (P19).	Leakage is not allowable.

CAUTION

If the thrust chamber throat plug is installed and not vented (burst diaphragm removed) during this test, the thrust chamber will be overpressurized.

ba. If thrust chamber throat plug is installed, make sure burst diaphragm is removed from plug; then deenergize mainstage control valve.	Mainstage control indication is lost.

NOTE

Steps bb through bf are applicable only when testing an engine at stage static-test sites. When testing an engine at KSC, proceed to step bg.

bb. Make sure that purge control valve shuttles by checking for audible flow of gas at valve vent line exit. If gas flow is detected, energize mainstage control valve. If gas flow is not detected, disregard steps bc through bf and proceed to step bg.

WARNING

Failure to observe safety requirements of step bc can result in injury to personnel.

bc. Direct all personnel to stand behind safety barriers or at a safe distance from engine when performing steps bd through bf.

bd. Increase pneumatic pressure to engine helium tank to 400 ±25 psig.

be. Deenergize mainstage control valve.

bf. Decrease pneumatic pressure to engine helium tank to 225-250 psig, and wait one minute for system pressure to bleed down to 225-250 psig.

Operation	Result
bg. Leak-test purge control valve outlet flange (P18), and purge lines from purge control valve to:	Leakage is not allowable.

(1) Oxidizer injector purge pressure tap (CN1) (P10).

(2) GG oxidizer purge line flange (P27).

(3) GG oxidizer injector pressure and purge line port GO5 on GG (L40) and GO5 line to auxiliary FI package.

bgA. On engines not incorporating MD150, MD280, or MD281 change, leak-test GG oxidizer injection pressure line from tee in line GO5 to static-test transducer.

bgB. Using pneumatic flowtester, leak-test GG oxidizer valve to injector (L39).	Leakage is not allowable.

bgC. On engines incorporating MD383 or MD384 change, leak test redundant purge check valve weld joints.

bh. Shut off helium pressure to helium tank.

bi. Open hand valve or vent adaptor 9025423 in boss in MFV closing control line to vent pressure from control system. After pressure has vented, close hand valve.

bj. Deenergize helium control valve.

bk. Pressurize helium tank to 1,400-1,600 psig.

bl. Leak-test connections and welds from helium tank to the following locations:	Leakage is not allowable.

(1) Pneumatic control package (P29 and P15).

(2) HELIUM TANK FILL customer connect.

(3) Helium tank pressure line NN1 to primary FI package on engines not incorporating MD269, MD282, MD290, MD313, or MD315 change or to primary and auxiliary FI packages on engines incorporating MD269, MD282, MD290, MD313, or MD315 change.

(4) On engines not incorporating MD150, MD280, or MD281 change, line from tee in NN1 line to static-test transducer.

bm. Decrease supply pressure to helium tank to zero.

Operation	Result
bn. Using pneumatic flowtester, measure leakage at HELIUM TANK FILL pneumatic supply line. Record as helium tank fill-check valve reverse leakage.	Maximum allowable leakage is 3 scim.
bo. Energize engine helium control valve.	Helium tank depressurizes.

bp. Using vent valve in boss in MFV closing control line, vent pressure from control system. After all pressure has vented, close vent valve and deenergize engine helium control valve.

bq. Remove vent valve or adapter from boss in MFV closing control line.

br. Install vent port check valve into boss in MFV closing control line. (Refer to R-3825-3.)

bs. If purge control valve vent line was disconnected, install new seal and connect vent line to purge control valve vent port. Torque bolts to 41-45 in-lb.

bt. Using tool T-5044445, install all tapered brass plugs in leak detection ports of pneumatic control system. (See figure 3-32.)

3.3.30 PRESSURE-DECAY-TESTING HELIUM SUPPLY SYSTEM. When performing this test, record all actuations and deactuations of the helium regulator and the pressure level of each operation in the Engine Log Book, Helium Regulator Assembly Operation Record. Refer to section II for checkout constraints before performing this test.

a. Connect a regulated supply of helium (refer to section II) capable of supplying a minimum of 1,600 psig to engine HELIUM TANK FILL customer connect.

b. Connect a monitoring system to engine connector P106, pins T, U, V, N, M, R, and Z. Monitoring system must be capable of monitoring helium tank pressure (NN1).

c. Slowly pressurize helium tank to 1,400 (+100, -0) psig.

d. Shut off pressure to HELIUM TANK FILL customer connect.

e. Energize helium tank emergency vent control valve. When helium tank pressure has decreased to zero, deenergize helium tank emergency vent control valve.

f. Slowly pressurize helium tank to 1,400 (+100, -0) psig.

g. After a minimum of one hour following initial helium tank pressurization (helium tank stabilization period), decrease pressure to HELIUM TANK FILL customer connect to zero. (Check valve isolates pressure in helium tank.)

h. Record helium tank pressure and time that pressure was recorded.

i. Wait 15 minutes, and record helium tank pressure.

j. Determine helium pressure decay by subtracting value recorded in step i from value recorded in step h.

k. A pressure decay rate of 90 psi per hour maximum is allowable. If pressure decay exceeds this value on initial check, wait 1/2 to one hour and repeat steps h through j. The pressure decay rate at the end of 3 hours must not exceed 90 psi per hour.

NOTE

To activate the helium control valve; the engine must be brought to the components test mode.

l. Vent helium tank pressure to zero by energizing engine helium control valve. Deenergize helium control valve.

m. Disconnect helium supply from HELIUM TANK FILL customer connect, and secure test equipment.

3.3.31 TESTING GAS GENERATOR AND EXHAUST SYSTEM. Refer to section II for checkout constraints before performing this test. Refer to paragraph 3.3.2 for seal leak-test points.

a. Remove plug and seal from torque access of fuel turbine exhaust duct.

b. On engines not incorporating MD172 change, install torque wrench to adapter 0019861-11 from wrench kit 0010711-11, insert through torque access, and engage splines of turbine shaft and adapter.

c. On engines incorporating MD172 change, install torque wrench to adapter 10-0025816 from wrench kit 0010711-21, insert through torque access, and engage hex on turbine wheel.

d. Rotate turbine wheel counterclockwise (viewed from turbine) a minimum of 5 complete revolutions.

e. Remove torque wrench and adapter.

f. Install exhaust system test plates (paragraph 3.3.3).

g. Remove protective covers from oxidizer and fuel turbine seal drain lines.

h. On engines incorporating MD234 change, remove bolts and washers that secure drain line to STDV, and remove seal.

i. Install test plate 0025390 from test plate kit 0025400-11 between line flange and STDV drain port. Torque bolts to 41-45 in-lb.

j. Connect a regulated supply of helium (refer to section II) capable of supplying 0-100 psig to adapter 0022823.

k. Connect a monitoring system that incorporates a bleed valve and is capable of monitoring 0-60 psig, to adapter 9022823.

l. Remove threaded plugs from leak detection ports as required during system test. (See figure 3-32.)

CAUTION

The pressure indicated on the monitor gage must not exceed 35 psi at any time during this test, since excessive pressure can damage the engine system.

m. Slowly apply pressure to adapter 9022823 until monitor gage indicates 30 ±1 psi.

Operation	Result
n. Using pneumatic flowtester, measure leakage at oxidizer turbine seal drain line. Record as oxidizer turbine seal leakage.	Maximum allowable leakage is 350 scim.
o. Connect hose from flowmeter to fuel turbine seal drain line. If range of flowtester is exceeded, use 2 flowmeters in parallel. (Refer to R-3825-6.) Record as fuel turbine seal leakage.	Allowable leakage is 6,000 scim more than leakage recorded in Engine Log Book during engine final acceptance checkout (form DD250 signoff), but not to exceed a maximum of 10,000 scim. If the fuel turbine seal has been replaced, allowable leakage is 6,000 scim more than leakage recorded in Engine Log Book during first leak check performed after seal replacement. (Refer to R-3825-3 for allowable leakage during first leak test after seal replacement.)
p. Using pneumatic flowtester, leak-test the following connections:	
(1) Fuel turbopump connection to turbine exhaust duct (G29).	Maximum allowable leakage is 3 scim.
(2) Fuel turbine inlet manifold connection to STDV hose (G22).	Maximum allowable leakage is one scim.
(3) STDV hose to STDV (F42).	Leakage is not allowable.
(4) Instrumentation port on STDV discharge hose (F53).	Leakage is not allowable.
(5) GG fuel valve to injector (F43).	Leakage is not allowable.
(6) (Deleted)	
(7) Crossover duct to oxidizer turbine inlet (G1).	Maximum allowable leakage is 3 scim.
(8) Oxidizer turbine to heat exchanger duct (G7).	Maximum allowable leakage is 3 scim.
(9) Oxidizer turbopump torque access port cover (G4).	Maximum allowable leakage is one scim.
(10) Oxidizer turbopump accessory drive pad (G5).	Maximum allowable leakage is one scim.

Operation	Result
(11) Oxidizer turbopump accessory drive pad access plug (G6) (hydraulic pump not installed).	Maximum allowable leakage is one scim.
(12) Fuel turbine outlet crossover duct drain port (G28).	
q. Leak-test plates installed at OTBV and downstream of heat exchanger.	Some gas flow past exhaust system test plates is allowable.
r. Leak-test the following instrumentation line connections to primary and auxiliary FI packages:	
(1) On engines not incorporating MD237 change, GG chamber pressure line GG1 (primary package) (G18).	Maximum allowable leakage is 0.3 scim.
(2) GG fuel injector pressure line GF4 (auxiliary package) (F44).	Leakage is not allowable.
(3) Oxidizer turbine inlet pressure line TG3 (auxiliary package) (G3).	Maximum allowable leakage is 0.3 scim.
(4) Oxidizer turbine outlet pressure line TG4 (auxiliary package) (G8).	Maximum allowable leakage is 0.3 scim.
(5) On engines incorporating MD237 change, fuel turbine inlet pressure instrumentation port TG1 (G31).	Maximum allowable leakage is 0.3 scim.
s. On engines not incorporating MD150, MD280, or MD281 change, leak-test the following instrumentation lines to respective stage static-test transducers. (Leak-test the instrumentation ports on engines incorporating MD150, MD280, or MD281 change.)	Maximum allowable leakage is 0.3 scim at hot-gas instrumentation ports.
(1) On engines not incorporating MD237 change, GG chamber pressure line GG1a from GG (G17).	
(2) On engines not incorporating MD226 or MD237 change, OTBV nozzle inlet pressure line TG8 from oxidizer turbine bypass duct (G15).	
(3) GG fuel injection pressure line from tee in line GF4.	
(4) (Deleted)	
(5) Oxidizer turbine outlet pressure line from tee in line TG4.	
t. Using pneumatic flowtester, measure reverse-flow leakage of GG fuel purge check valve. Record as GG fuel purge check valve reverse leakage.	Maximum allowable leakage is 100 scim.
u. If fuel turbine seal purge check valve reverse leakage recorded in paragraph 3.3.27.1 exceeded 100 scim and exhaust system test plates were installed, subtract leakage recorded in step t from leakage recorded in paragraph 3.3.27.1. Record difference as fuel turbine seal purge check valve reverse leakage.	
v. Leak-test the following instrumentation taps:	Maximum allowable leakage is 0.3 scim at hot-gas instrumentation ports.
(1) On engines not incorporating MD237 change, OTBV nozzle inlet pressure port TG8 (G15).	
(2) On engines not incorporating MD136 change, fuel turbine inlet pressure instrumentation port TG1a (G10).	

(3) On engines not incorporating MD237 change, fuel turbine inlet temperature transducer TGT1a (G20).

(4) On engines not incorporating MD136 or MD237 change, fuel turbine inlet pressure instrumentation port TG1 (G21).

(5) GG spark igniter "A" port (G23).

(6) Fuel turbine inlet temperature transducer TGT1 (G24).

(7) GG overtemperature transducer GGT1 (G25).

(8) Fuel turbine exhaust temperature transducer TGT2 (G26).

(9) Fuel turbine exhaust pressure transducer port TG2 (G27).

(10) GG spark igniter "B" port (G30).

(11) On engines not incorporating MD237 change, fuel turbine inlet temperature transducer port TGT1b (G31).

(12) Oxidizer turbine inlet temperature transducer TGT3 (G2).

(13) Oxidizer turbine outlet temperature transducer TGT4 (G9).

(14) Heat exchanger ports (above heat exchanger test plate) (G10 and G11).

(15) On engines not incorporating MD237 change, OTBV nozzle inlet temperature transducer TGT6 (G16).

WARNING

Make sure monitor gage indicates zero before proceeding.

Operation	Result
w. Decrease exhaust system pressure to zero.	Monitor gage indicates zero.

x. On engines incorporating MD234 change, perform steps y through ag. On engines not incorporating MD234 change, proceed to step ah.

y. Remove bolts and washers that secure STDV drain line to STDV, and remove test plate.

z. Install new seal, and connect drain line to STDV with bolts and washers. Torque bolts to 42-45 in-lb, and safetywire.

aa. Install test adapter 9024523 from adapter kit 9024496 on exit end of fuel turbine seal drain line at thrust chamber exit.

ab. Disconnect pneumatic monitor hose from test adapter 9022823, and connect pneumatic monitor hose to adapter 9024523 on fuel turbine seal cavity bleed line.

ac. Install cap on fitting of test adapter 9022823 installed on torque access of fuel turbopump turbine exhaust duct.

ad. Slowly apply pressure to adapter 9022823 until monitor gage indicates 30 ±1 psi.

Operation	Result
ae. Leak-test drain line flange at STDV (G32).	Leakage is not allowable.
af. Decrease exhaust system pressure to zero.	Monitor gage indicates zero.

ag. On engines incorporating MD234 change, remove test adapter 9024523 from exit end of fuel turbine seal drain line, and install protective closure on line.

ah. Remove exhaust system test plates (paragraph 3.3.4) unless a thrust chamber test is to be performed on an engine not incorporating MD301, MD302, MD322, or MD323 change.

NOTE

Steps ai through ay leak-test the OTBV opening and closing control line flange seals. This test may be disregarded if a pneumatic control system test is to be performed or if the exhaust system test plates were not removed.

- Steps ai through am are applicable when testing an engine at stage static-test sites. When testing an engine at KSC, proceed to step at.

ai. Energize helium and mainstage control valve.

WARNING

Failure to observe safety requirements of step aj can result in injury to personnel.

aj. Direct all personnel to stand behind adequate safety barriers or at a safe distance from engine when performing steps ak through am.

ak. Apply 400-1,600 psig helium pressure to helium tank.

al. Deenergize mainstage control valve.

am. Decrease helium pressure entering helium tank to 225-250 psig, and wait one minute for system pressure to bleed down to 225-250 psig.

Operation	Result
an. Using pneumatic flowtester, leak-test OTBV opening control port flange (P22).	Leakage is not allowable.

ao. Energize ignition-phase and mainstage control valves.

Operation	Result
ap. Using pneumatic flowtester, leak-test OTBV closing control port flange (P21).	Leakage is not allowable.

aq. Deenergize mainstage and ignition-phase control valves.

ar. Decrease pressure to helium tank to zero.

as. Allow all pressure to vent from helium tank. Deenergize helium control valve.

NOTE

Steps at through az are applicable to engines at KSC only.

at. Energize helium, ignition-phase, and mainstage control valves.

au. Apply 600-1,600 psig helium pressure to helium tank.

Operation	Result
av. Using pneumatic flowtester, leak-test OTBV closing control port flange (P21).	Leakage is not allowable.

aw. Deenergize mainstage and ignition-phase control valves.

Operation	Result
ax. Using pneumatic flowtester, leak-test OTBV opening control port flange (P22).	Leakage is not allowable.

ay. Decrease pressure to helium tank to zero.

az. Allow all pressure to vent from helium tank. Deenergize helium control valve.

ba. Reinstall threaded plugs in leak detection ports and torque to 22-28 in-lb. (Safetywire plugs after prelaunch leak tests.)

3.3.32 LEAK-TESTING THRUST CHAMBER. Refer to section II for checkout constraints before performing this test. Refer to paragraph 3.3.2 for seal leak-test points.

a. Remove thrust chamber exit closure.

b. Remove protective closure from purge control valve vent line (at thrust chamber exit).

c. Install Presstite tape, Type 587.3 (Interchemical Corp), and cover with 2-inch-wide Teflon Temp-R-Tape, Type C (Connecticut Hard Rubber Co), in thrust chamber throat plug seating area as follows:

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

(1) Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe a 4-inch portion of thrust chamber throat approximately 9 inches down from injector face or approximately 4 inches from throat.

(2) Cut two 28 ±1 inch pieces of 1/2-inch-wide Presstite tape.

(3) Cover Presstite tape with Teflon Temp-R-Tape. Press tape slightly to make sure tape sticks to Presstite tape.

(4) Remove paper backing from the 2 strips of tape, and install tape around inside of thrust chamber throat approximately 11 inches from face of injector or approximately 6 inches from throat. Trim ends, as necessary, to make one continuous band of tape. Make sure tape ends are pressed firmly together. Press tape slightly with fingers as required, to make tape stay in place.

(5) Cut a 4-inch piece of Presstite tape. Place tape on workbench with paper backing facing workbench. Cut tape into 2 pieces 1/4 inch wide by 4 inches in length.

(6) Place throat plug half that contains burst diaphragm, on workbench with flat up. Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe flat.

(7) Install the two 4-inch pieces of tape on flat of throat plug. Stretch each piece to width of flat, and install on each side of hole to form 2 seals on flat. Cover each piece of Presstite tape with Teflon Temp-R-Tape. Press tape slightly with fingers, as required, to make tape stay in place. Trim ends of tape at each end flush with edge of flat.

NOTE

Thrust Chamber Throat Plug Kit G3120MD3 must be installed dry (no lubricant).

d. Place hand screw in throat plug in stowed position to prevent movement during plug installation.

e. Install half of throat plug into thrust chamber combustion area with handle-equipped end facing thrust chamber exit. Make sure throat plug half does not disturb tape.

f. Install other half of throat plug, and mate halves of plug. Make sure tape strips on flat stay in place during plug installation.

g. Grasp handles, and pull sections together toward throat area until a tight fit is obtained.

h. Connect a monitoring system that incorporates a bleed valve and is capable of measuring 0-60 psig to thrust chamber throat plug monitor port. A regulated supply of helium (refer to section II) capable of pressurizing thrust chamber to 30 ±5 psig may also be connected to thrust chamber throat plug monitor port, using tee fitting.

hA. On engines incorporating MD383 or MD384 change, remove plug from oxidizer injector pressure tap CN1.

i. Isolate stage fuel tank pressurization system from engine HYDROGEN TANK PRESSURIZATION customer connect (not applicable on SII-stage center engine).

CAUTION

The brass tube (which looks like a brass plug) must not be removed from the seal at the start tank liquid refill line flange of the ASI fuel line.

j. Remove threaded plugs from leak detection ports as required during system test. (See figure 3-32.)

CAUTION

Pressure indicated on the monitor gage must not exceed 35 psi any time during the test.

k. Apply helium through thrust chamber jacket purge customer connect or through throat plug monitor port until monitor gage on thrust chamber throat plug indicates 30 ±5 psi.

Operation	Result
1. Leak-test the following connections and lines:	Leakage is not allowable.

(1) MOV downstream flange (L33).

(2) MFV downstream flange (F41).

(3) ASI fuel line at main fuel inlet manifold (F37).

(3) Cover Presstite tape with Teflon Temp-R-Tape. Press tape slightly to make sure tape sticks to Presstite tape.

(4) Remove paper backing from the 2 strips of tape, and install tape around inside of thrust chamber throat approximately 11 inches from face of injector or approximately 6 inches from throat. Trim ends, as necessary, to make one continuous band of tape. Make sure tape ends are pressed firmly together. Press tape slightly with fingers as required, to make tape stay in place.

(5) Cut a 4-inch piece of Presstite tape. Place tape on workbench with paper backing facing workbench. Cut tape into 2 pieces 1/4 inch wide by 4 inches in length.

(6) Place throat plug half that contains burst diaphragm, on workbench with flat up. Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, hand-wipe flat.

(7) Install the two 4-inch pieces of tape on flat of throat plug. Stretch each piece to width of flat, and install on each side of hole to form 2 seals on flat. Cover each piece of Presstite tape with Teflon Temp-R-Tape. Press tape slightly with fingers, as required, to make tape stay in place. Trim ends of tape at each end flush with edge of flat.

NOTE

Thrust Chamber Throat Plug Kit G3120MD3 must be installed dry (no lubricant).

d. Place hand screw in throat plug in stowed position to prevent movement during plug installation.

e. Install half of throat plug into thrust chamber combustion area with handle-equipped end facing thrust chamber exit. Make sure throat plug half does not disturb tape.

f. Install other half of throat plug, and mate halves of plug. Make sure tape strips on flat stay in place during plug installation.

g. Grasp handles, and pull sections together toward throat area until a tight fit is obtained.

h. Connect a monitoring system that incorporates a bleed valve and is capable of measuring 0-60 psig to thrust chamber throat plug monitor port. A regulated supply of helium (refer to section II) capable of pressurizing thrust chamber to 30 ±5 psig may also be connected to thrust chamber throat plug monitor port, using tee fitting.

i. Isolate stage fuel tank pressurization system from engine HYDROGEN TANK PRESSURIZATION customer connect (not applicable on SII-stage center engine).

CAUTION

On engines incorporating MD327, MD328, MD329, MD332, or MD344 change, the brass tube (which looks like a brass plug) must not be removed from the seal at the start tank liquid refill line flange of the ASI fuel line.

j. Remove threaded plugs from leak detection ports as required during system test. (See figure 3-32.)

CAUTION

Pressure indicated on the monitor gage must not exceed 35 psi any time during the test.

k. Apply helium through thrust chamber jacket purge customer connect or through throat plug monitor port until monitor gage on thrust chamber throat plug indicates 30 ±5 psi.

Operation	Result
l. Leak-test the following connections and lines:	Leakage is not allowable.

(1) MOV downstream flange (L33).

(2) MFV downstream flange (F41).

(3) ASI fuel line at main fuel inlet manifold (F37).

CAUTION

The brass tube on the side of the plate seal at the leak-detection port must not be removed. (This tube looks like a leak-detection-port brass plug.)

(4) Start tank liquid refill line flange on ASI fuel line (F50). When leak-testing seal, remove plastic cap on tube at leak-detection port. Reinstall cap after test.

(5) On engines incorporating MD331 or MD344 change but not incorporating MD347 change, start tank liquid refill line from ASI fuel line to start tank support-and-fill valve.

(6) On engines not incorporating MD254, MD327, MD328, MD329, MD331, MD332, MD344, or MD347 change, start tank refill line from tee in ASI fuel line to tank support-and-fill valve.

(7) ASI oxidizer line to ASI valve (L32).

(8) On engines not incorporating MD254 or MD347 change, start tank gaseous refill line to start tank support-and-fill valve (F35).

(9) Start tank gaseous refill line connection to forward fuel manifold (F34).

(10) Flange bleed point between ASI injector and thrust chamber injector (L35).

(11) Thrust chamber purge line from check valve to fuel manifold (F30).

(12) On engines not incorporating MD156 change and on engines incorporating MD182 change, HYDROGEN TANK PRESSURIZATION customer connect line (F33).

NOTE

MD156 change removes and MD182 change reinstalls the HYDROGEN TANK PRESSURIZATION line.

(13) On engines incorporating MD156 change, plate on fuel tank pressurization flange (F33).

(14) Oxidizer injector purge check valve to MOV (P36).

(15) Mainstage OK pressure switches No. 1 and No. 2 to thrust chamber (L37 and L38).

(16) Upper and lower ASI fuel line flange connection (F49).

(17) Main injector to thrust chamber manifold (F30).

(18) On engines not incorporating MD330 change, ignition detector probe flange (G14).

(19) On engines incorporating MD330 change, ASI combustion temperature probe flange (G14).

(20) Thrust chamber turnaround manifold drain screws (8 places).

Operation	Result
m. Leak-test connections of the following instrumentation lines to primary and auxiliary FI packages:	
(1) Thrust chamber pressure port CG1 (G12).	Leakage is not allowable.
(2) Thrust chamber pressure line CG1 (primary FI package).	Leakage is not allowable.
(3) Fuel manifold main fuel injection pressure line CF2 (auxiliary FI package) (F23).	Leakage is not allowable.
(4) Main oxidizer injection pressure line CO3 (auxiliary FI package) (L34).	Leakage is not allowable.

n. On engines not incorporating MD150, MD280, or MD281 change, leak-test applicable connections of the following stage static-test instrumentation lines to respective static-test transducers: (Leak-test the instrumentation ports on engines incorporating MD150, MD280, or MD281 change.)

Operation	Result
(1) Thrust chamber pressure line from tee in line CG1.	Leakage is not allowable.
(2) Thrust chamber pressure line CG1a from thrust chamber (G13).	Leakage is not allowable.
(3) Main fuel injection pressure line CF2a from fuel manifold to static-test transducer (F24).	Leakage is not allowable.
(4) On engines not incorporating MD192 or MD246 change, ASI chamber pressure line IG1 from oxidizer dome to static-test transducer.	Leakage is not allowable.
o. Leak-test the following instrumentation taps:	Leakage is not allowable.

(1) Fuel inlet manifold port below MFV (F40).

(2) Fuel inlet manifold drain port (F38).

(3) Fuel inlet manifold port (180 degrees from MFV) (F36).

(4) On engines not incorporating MD327, MD328, MD329, MD332, or MD344 change, ASI fuel injector temperature IFT1 (F27).

(5) On engines not incorporating MD327, MD328, MD329, MD332, or MD344 change but incorporating MD237 change, ASI fuel injection pressure port IF2 (F28).

(6) Drain port on thrust chamber forward fuel manifold (F25).

(7) Main fuel injector temperature probe CFT2 (F31).

(8) Drain port on thrust chamber fuel manifold (F26) (located below port CFT2).

(9) Thrust chamber dome port CO3A (L36) (oxidizer dome purge connection for static test).

(10) On engines not incorporating MD262 change, main fuel injector temperature probe CFT2a (F51).

Operation	Result
p. Using pneumatic flowtester, measure leakage at purge control valve vent exit or, on engines incorporating MD383 or MD384 change, at pressure tap CN1. Record actual value as oxidizer dome purge check valve reverse leakage.	Maximum allowable leakage is 80 scim.

q. Remove MOV linkage housing vent port check valve and MOV idler shaft vent port check valve.

r. Remove MFV linkage housing vent port check valve and MFV idler shaft vent port check valve.

Operation	Result
s. Using pneumatic flowtester, measure leakage at vent port on MOV linkage housing. Record as MOV drive shaft seal leakage.	Maximum allowable leakage is 10 scim.
t. Using pneumatic flowtester, measure leakage at vent port on MOV idler shaft housing. Record as MOV idler shaft seal leakage.	Maximum allowable leakage is 10 scim.
u. Using pneumatic flowtester, measure leakage at vent port on MFV linkage housing. Record as MFV drive shaft seal leakage.	Maximum allowable leakage is 10 scim.
v. Using pneumatic flowtester, measure leakage at vent port on MFV idler shaft housing. Record as MFV idler shaft seal leakage.	Maximum allowable leakage is 10 scim.

w. Install vent port check valves in MOV and MFV. (Refer to R-3825-3.)

Operation	Result
x. Shut off thrust chamber pressurization helium supply.	Monitor gage connected to thrust chamber throat plug indication remains at 30 ±5 psi.

y. Disconnect regulated pneumatic system from THRUST CHAMBER JACKET PURGE customer connect.

Operation	Result
a. Using pneumatic flowtester, measure leakage through THRUST CHAMBER JACKET PURGE customer connect system. Record as fuel jacket purge check valve reverse leakage.	Maximum allowable leakage is 100 scim.
aa. Open bleed valve on monitor system connected to thrust chamber throat plug.	Monitor gage must indicate zero.

ab. Return stage fuel tank pressurization system to pre-test configuration. (Reconnect stage fuel tank pressurization line.)

ac. Remove protective cover from START TANK VENT & RELIEF VALVE DRAIN customer connect.

Operation	Result
ad. Apply 550 psia maximum pneumatic pressure to START TANK VENT VALVE CONTROL customer connect.	Start tank pressure vents.

ae. Decrease pneumatic pressure to START TANK VENT VALVE CONTROL customer connect to zero.

af. Install protective cover on START TANK VENT & RELIEF VALVE DRAIN customer connect.

afA. On engines incorporating MD383 or MD384 change, install new seal and reinstall plug in pressure tap CN1. Torque plug to 66-73 in-lb and safetywire.

ag. Disconnect monitoring system from thrust chamber throat plug, and disconnect regulated pneumatic system (if used).

NOTE

The burst diaphragm is removed to prevent accidental pressurization of the thrust chamber.

ah. If throat plug is to remain installed for subsequent thrust chamber repressurizing, remove burst diaphragm from throat plug until repressurization is required. (When reinstalling burst diaphragm, torque to 135-165 in-lb.) If throat plug is to be removed, proceed as follows:

(1) Move hand screw on throat plug from stowed position to operating position, and rotate hand screw until one half of throat plug slides forward. Place hand screw in stowed position.

(2) Push throat plug into combustion area.

(3) Rotate one half of throat plug and disengage from pivot.

(4) Remove throat plug sections from thrust chamber.

WARNING

The following procedure specifies trichloroethylene, which is a toxic solvent. Inhalation of its vapors or prolonged contact with the liquid can cause serious injury or death.

ai. Remove tape from thrust chamber throat and throat plug. Using a lint-free cloth dampened with trichloroethylene (MIL-T-27602), or equivalent, handwipe throat area where tape was installed, to make sure area is clean.

aj. Install thrust chamber exit closure. (Tighten nuts handtight plus 1/4 turn.) If thrust chamber diffuser is installed, secure exit closure with 20 tension springs RD305-44050. (Refer to section II for desiccant installation requirement.)

ak. Reinstall threaded plugs in leak detection ports and torque to 22-28 in-lb. (Safetywire plugs after prelaunch leak tests.)

3.3.33 TESTING ENGINE ELECTRICAL SAFETY CIRCUIT.

a. Provide instrumentation to record sequence signals.

WARNING

Failure to observe safety requirements can result in injury to personnel.

CAUTION

Performing the engine electrical safety circuit test with pressure in the start tank can cause damage (dry-spinning) to the fuel turbine.

- Performing the test with pressure in the helium tank will unnecessarily operate engine valves and can damage the engine propellant flowmeters by causing dry-spinning in excess of 60 seconds if the stage propellant tanks are pressurized and the prevalves are open.
- If engine ignition power bus is energized during electrical safety circuits test, a time lapse of approximately 5 minutes must be maintained between each of the following tests to allow the spark exciters to cool.

b. Turning on ignition-power during electrical safety circuits test is optional.

c. Make sure engine start tank and helium tank are not pressurized.

3.3.33.1 Testing for Delay in Receiving Mainstage Enable Signal. This test checks the ability to stop engine sequence for 3- or 8-second fuel lead used on the SIVB stage. This test is not required for engines installed in an SII stage, since a continuous signal is supplied to the mainstage enable circuit. The SII stage has no requirement for fuel leads over one second, which are provided by the engine STDV delay timer.

Operation	Result
a. Energize engine ignition and control power buses.	(1) Engine-ready indication is obtained.

CAUTION

Whenever an ignition-complete indication has been obtained, the ignition detection simulation circuit (electrical connector P54, pin M) must not be energized, since it will result in sending a redundant signal to the ECA ignition-complete circuit, which could result in damage to the ECA.

Operation	Result
	(2) On engines incorporating MD338 change, ignition-complete indication is obtained.
b. On engines not incorporating MD338 change, energize ignition detection simulation circuit.	Ignition-complete indication is obtained.

NOTE

On engines incorporating MD338 change, the ignition-complete indication is obtained through the dummy ignition detector probe.

Operation	Result
c. Start recorders, and momentarily energize engine start circuit.	Engine-ready indication goes off, helium control and ignition-phase control valves are energized, and engine sequence stops.
d. Within 10-12 seconds after step c, energize mainstage enable circuit.	

Operation	Result

NOTE

Engine sequence continues and the STDV control valve is energized for 0.45 second (ignition-phase timer, after which the mainstage control valve is energized.

Operation	Result
e. Approximately 0.7 second after mainstage control valve energized indication is obtained, energize mainstage OK bypass circuit.	Mainstage OK No. 1 and No. 2 indications are obtained.
f. Between 10-12 seconds after step e, momentarily energize engine cutoff command circuit.	Ignition-phase and mainstage control valve indications go off, and one second later, helium control valve energized indication goes off.
g. Deenergize mainstage OK bypass circuit. After engine-ready indication is obtained, stop recorders.	Mainstage OK No. 1 and mainstage OK No. 2 indications go off.
h. On engines not incorporating MD338 change, deenergize ignition detection simulation circuit.	Ignition-complete indication goes off.

i. Deenergize mainstage enable circuit.

j. Deenergize engine control and ignition power buses.

3.3.33.2 Testing for Failure to Receive Ignition-Detected Signal After Engine Start (Engines Not Incorporating MD338 Change). On engines incorporating MD338 change, this test is not required, since ignition-complete indication is obtained through the dummy ignition detector probe.

Operation	Result
a. Energize engine ignition and control power buses.	Engine-ready indication is obtained.

NOTE

When testing engines installed in an SII stage, step b is not required, since a continuous signal is supplied to the mainstage enable circuit.

Operation	Result
b. On engines installed in an SIVB stage, energize mainstage enable circuit.	
c. Start recorders, and momentarily energize engine start circuit.	Engine start sequence begins, and the following indications result: (1) Engine-ready indication goes off. (2) Helium control and ignition-phase control valves energized indications are obtained.

Operation	Result
	(3) After 1.00 second STDV control valve energized indication is obtained.
	(4) 0.45 second after result (3), engine cutoff automatically occurs deenergizing all engine control valves except helium control.
	(5) One second after engine cutoff, helium control valve is deenergized and engine-ready indication is obtained.

d. Stop recorders, and deenergize circuit energized in step b.

e. Deenergize engine control and ignition power buses.

3.3.33.3 Testing for Failure to Receive Mainstage OK Signal After Engine Start.

Operation	Result
a. Energize engine ignition and control power buses.	Engine-ready indication is obtained.

CAUTION

Whenever an ignition-complete indication has been obtained, the ignition detection simulation circuit (electrical connector P54, pin M) must not be energized, since it will result in sending a redundant signal to the ECA ignition-complete circuit, which could result in damage to the ECA.

NOTE

When testing engines installed in an SII stage, step b is not required, since a continuous signal is supplied to the mainstage enable circuit.

Operation	Result
b. On engines installed in an SIVB stage, energize mainstage enable circuit.	On engines incorporating MD338 change, ignition-complete indication is obtained.

NOTE

On engines incorporating MD338 change, ignition-complete is obtained through the dummy ignition detector probe.

Operation	Result
c. On engines not incorporating MD338 change, energize ignition detection simulation circuit.	Ignition-complete indication is obtained.
d. Start recorders, and momentarily energize engine start circuit.	Engine start sequence begins, and the following indications result:
	(1) Engine-ready indication goes off.
	(2) Helium control and ignition phase control valve indications are obtained.

Operation	Result
	(3) After 1.00 second, STDV energized indication is obtained.
	(4) Mainstage control valve indication is obtained.
	(5) Engine cutoff automatically occurs 3.3 seconds after result (4), deenergizing all engine control valves except helium control.
	(6) One second after engine cutoff, helium control valve is deenergized and engine-ready indication is obtained.

e. Stop recorders, and deenergize circuit energized in step b.

f. Deenergize engine control and ignition power buses.

3.3.34 TESTING MAINSTAGE OK PRESSURE SWITCHES. Refer to section II for checkout constraints before performing this test.

a. Connect a regulated supply of helium (refer to section II) capable of supplying 0-1,000 psig to CALIPS CHECKOUT LINE customer connect. (Use test adapter kit 9025405 if interface line is not connected.)

b. Provide instrumentation to monitor mainstage OK pressure switches actuation and deactuation signals.

WARNING

Failure to observe safety requirements can result in injury to personnel.

c. Direct all personnel to stand behind adequate safety barriers or at a safe distance from engine while performing this test.

d. Adjust pneumatic pressure to calips checkout line to 600 ±25 psig.

e. Decrease pneumatic pressure to zero.

f. Energize engine control power bus.

Operation	Result
g. Slowly increase pneumatic pressure to a maximum of 600 psig. Record No. 1 pressure switch actuation pressure.	(1) No. 1 pressure switch must actuate at 500±30 psig.
	(2) Mainstage OK No. 1 pressure switch and mainstage OK No. 2 pressure switch indications come on.
h. Slowly decrease pneumatic pressure. Record No. 1 pressure switch deactuation pressure.	(1) No. 1 pressure switch must deactuate at 20-105 psig below actuation pressure.
	(2) Mainstage OK No. 1 pressure switch and mainstage No. 2 pressure switch indications go off.

i. Decrease pneumatic pressure to zero.

j. Repeat steps g through i.

Operation	Result
k. Slowly increase pneumatic pressure to a maximum of 600 psig. Record No. 2 pressure switch actuation pressure.	(1) No. 2 pressure switch must actuate at 500±30 psig.
	(2) Mainstage OK No. 1 pressure switch and mainstage OK No. 2 pressure switch indications come on.

Operation	Result
l. Slowly decrease pneumatic pressure. Record No. 2 pressure switch deactuation pressure.	(1) No. 2 pressure switch must deactuate at 20-105 psig below actuation pressure.
	(2) Mainstage OK No. 1 pressure switch and mainstage OK No. 2 pressure switch indications go off.

m. Decrease pneumatic pressure to zero.

n. Repeat steps k through m.

o. Deenergize engine control power bus.

p. If stage interface pressure line was not used, disconnect test hose and adapter from CALIPS CHECKOUT LINE customer connect and install cap on customer connect.

3.3.35 PRESSURE-DECAY-TESTING MAINSTAGE OK PRESSURE SWITCHES. Refer to section II for checkout constraints before performing this test.

a. Remove cap from CALIPS CHECKOUT LINE customer connect and install test adapter 9025406 from test adapter kit 9025405.

b. Connect a regulated supply of helium (refer to section II) capable of supplying 410 psig to test adapter 9025406. Pneumatic supply system must be capable of locking pressure in pressure switches and must incorporate a monitor gage (0-600 psi), pressure relief valve (450 psi maximum), and bleed valve on pressure switch side of shutoff valve. Locate shutoff valve and monitor gage within first 3 feet of line length from customer connect.

c. Slowly adjust pressure until monitor gage indicates 90-100 psi.

NOTE

All test connections and equipment must be free of leakage to make sure pressure-decay test results are valid.

Operation	Result
d. Leak-test connections in supply system and line from test connection to pressure switches.	Leakage is not allowable.

e. Slowly increase pressure until monitor gage indicates 400 ±10 psi. Close shutoff valve in pneumatic supply system to isolate pressure to switches. Vent supply pressure to shutoff valve to zero. Record pressure indicated on monitor gage.

f. Wait 15 minutes; then record pressure indicated on monitor gage.

g. Vent pneumatic pressure to zero.

h. Subtract pressure recorded in step f from pressure recorded in step e. Record difference as pressure decay.

i. If pressure decay does not exceed 10 psi, pressure switches are acceptable; proceed to step o.

j. If pressure decay exceeds 10 psi, disconnect calips checkout line from No. 2 pressure switch at elbow.

k. Install plug AN806-4 on end of line to No. 2 pressure switch. Torque connection to 135-185 in-lb.

l. Repeat steps c through g. If pressure decay between steps e and f exceeds 10 psi, No. 1 pressure switch is not acceptable. If pressure decay does not exceed 10 psi, subtract pressure decay from pressure recorded in step h. If difference exceeds 10 psi, No. 2 pressure switch is not acceptable.

m. Remove plug from line to No. 2 pressure switch, and reconnect line to switch. Torque fitting to 135-185 in-lb.

n. If pressure switch was replaced during this test, repeat test starting with step c.

o. Disconnect helium supply system, and remove test adapter from CALIPS CHECKOUT LINE customer connect. Reinstall cap on customer connect.

3.3.36 TESTING AUGMENTED SPARK IGNITER AND GAS GENERATOR SPARK IGNITER. The spark exciters are designed for a duty cycle of 10 seconds on and 5 minutes off, or 5 seconds on and 3 minutes off. The time intervals must not be exceeded during this test. An ASI chamber blocking device must be used to muffle sound interference from ASI spark igniters to enable audible verification of GG Spark Igniter operation.

CAUTION

Exceeding the duty cycle time intervals can cause damage to spark exciters and require replacement of the ECA or spark igniter cables.

NOTE

If a blocking device that meets the requirements of step a has been fabricated and is available, proceed to step b.

a. Fabricate an ASI chamber blocking device that meets the following requirements: (Figure 3-5 illustrates a typical blocking device.)

(1) Handle of blocking device must be a wood, plastic, or metal rod long enough to reach through thrust chamber throat to ASI chamber port with engine installed in SII or SIVB stacked or unstacked stage.

(2) Sound-muffling portion of blocking device must be a rubber or soft plastic conical or spherical tip secured to rod. Tip diameter (if a sphere) or width (at base, if a cone) should be 1-1/2 to 2 inches.

b. In steps c and e, when detecting GG spark igniter operation, insert ASI chamber blocking device through thrust chamber throat and hold tip of blocking device against ASI chamber port. Do not force tip of blocking device into port.

Operation	Result
c. Apply 28 vdc to pin Z of electrical plug P54. Using a stethoscope, listen for and detect an audible indication of No. 1 GG igniter operation of No. 1 ASI spark through thrust chamber exit.	(1) GG igniter spark-on indication is obtained.
	(2) ASI spark-on indication is obtained.
	(3) No. 1 ASI spark operation is detected (visually).
	(4) No. 1 GG spark igniter operation is detected (audibly).
d. Remove voltage applied to pin Z.	(1) GG igniter spark-on indication goes off.
	(2) ASI spark-on indication goes off.
e. Apply 28 vdc to pin X of electrical plug P54. Using a stethoscope, listen for and detect an audible indication of No. 2 GG spark igniter operation. Visually observe operation of No. 2 ASI spark through thrust chamber exit.	(1) GG igniter spark-on indication is obtained.
	(2) ASI spark-on indication is obtained.
	(3) No. 2 ASI spark operation is detected (visually).
	(4) No. 2 GG spark igniter operation is detected (audibly).
f. Remove voltage applied to pin X.	(1) GG igniter spark-on indication goes off.
	(2) ASI spark-on indication goes off.

3.3.37 ENGINE SEQUENCE TESTING. When performing this test, record all actuations and deactuations of the helium regulator and the pressure level of each operation in the Engine Log Book, Helium Regulator Assembly Operation

Record. Refer to section II for checkout constraints before performing this test. (See figure 3-49B for valve position switch voltages.)

a. Determine MOV temperature using a strap-on thermocouple or portable pyrometer, and record temperature.

NOTE

On engines installed in an SII stage, all five engine MOV temperatures should be measured and recorded. If this is not possible, a minimum of one outboard engine and the center engine MOV temperatures must be recorded.

b. Remove protective covers from the following:

(1) Thrust chamber exit (or one desiccant access cover from exit closure).

(2) Oxidizer turbopump primary seal drain line (stage overboard drain line on engines incorporating MD301, MD302, MD322, or MD323 change).

(3) Oxidizer turbopump intermediate seal-purge check valve vent.

(4) Purge control valve vent line.

WARNING

Failure to observe safety requirements of step c can result in injury to personnel.

c. Direct all personnel to stand behind adequate safety barriers or at a safe distance from engine while performing this test.

CAUTION

Opening the MFV or the MOV with the stage propellant tanks pressurized and the pre-valves open or with more than 5 psig in the inlet ducts with the pre-valves closed can damage the engine oxidizer and fuel flowmeters by dry-spinning in excess of 60 seconds.

d. Verify that pressure in the propellant inlet ducts is not greater than 5 psig and that the stage pre-valves are closed.

Valve	Engine Condition		
	Engine Ready	Ignition Phase	Mainstage
MFV	0.1 - 0.9	-	4.1 - 4.9
MOV	0.1 - 0.9	-	4.1 - 4.9
STDV	0.1 - 0.9	4.1 - 4.9	-
GG Control Valve	0.1 - 0.9	-	3.7 - 4.0
OTBV	4.1 - 4.9	-	0.1 - 0.9
	High Mixture Ratio		Low Mixture Ratio
MRCV (MD371 Change)	0.09 - 0.89	-	1.39 - 2.69
MRCV (MD366 Change)	1.48 - 1.98	-	2.08 - 2.98

Figure 3-49B. Valve Position Switch Voltages

Record. Refer to section II for checkout constraints before performing this test.

a. Determine MOV temperature using a strap-on thermocouple or portable pyrometer, and record temperature.

NOTE

On engines installed in an SII stage, all five engine MOV temperatures should be measured and recorded. If this is not possible, a minimum of one outboard engine and the center engine MOV temperatures must be recorded.

b. Remove protective covers from the following:

(1) Thrust chamber exit (or one desiccant access cover from exit closure).

(2) Oxidizer turbopump primary seal drain line (stage overboard drain line on engines incorporating MD301, MD302, MD322, or MD323 change).

(3) Oxidizer turbopump intermediate seal-purge check valve vent.

WARNING

Failure to observe safety requirements of step c can result in injury to personnel.

c. Direct all personnel to stand behind adequate safety barriers or at a safe distance from engine while performing this test.

CAUTION

Opening the MFV or the MOV with the stage propellant tanks pressurized and the pre-valves open or with more than 5 psig in the inlet ducts with the pre-valves closed can damage the engine oxidizer and fuel flowmeters by dry-spinning in excess of 60 seconds.

d. Verify that pressure in the propellant inlet ducts is not greater than 5 psig and that the stage pre-valves are closed.

e. Provide instrumentation to record sequence signals, spark monitor signals, and all valve position potentiometers.

f. Slowly apply pressure of 1,400-3,200 psig to engine helium tank. Maintain a minimum pressure of 800 psig during sequence test.

CAUTION

Performing engine sequence test with pressure in the start tank can damage the engine by causing dry-spinning of the fuel turbine.

Operation	Result
g. Apply 550 psia maximum pneumatic pressure to START TANK VENT VALVE CONTROL customer connect.	Any pressure in start tank vents.

h. Decrease pneumatic pressure to START TANK VENT VALVE CONTROL customer connect to zero.

i. Set a facility cutoff timer for 10-12 seconds.

CAUTION

Whenever an ignition-complete indication has been obtained, the ignition detection simulation circuit (electrical connector P54, pin M) must not be energized, since it will result in sending a redundant signal to the ECA ignition-complete circuit, which could result in damage to the ECA.

j. Energize engine ignition and control power buses.	(1) Voltage from ignition and control voltage monitor circuits. Voltage must be within limits outlined in section II.
	(2) Engine-ready indication is obtained.
	(3) On engines incorporating MD338 change, ignition-complete indication is obtained.

NOTE

On engines incorporating MD338 change, the ignition-complete indication is obtained through the dummy ignition detector probe.

k. On engines not incorporating MD338 change, energize ignition detection simulation circuit.	Ignition-complete indication is obtained.

e. Provide instrumentation to record sequence signals, spark monitor signals, and all valve position potentiometers.

f. Slowly apply pressure of 1,400-3,200 psig to engine helium tank. Maintain a minimum pressure of 800 psig during sequence test.

CAUTION

Performing engine sequence test with pressure in the start tank can damage the engine by causing dry-spinning of the fuel turbine.

Operation	Result
g. Apply 550 psia maximum pneumatic pressure to START TANK VENT VALVE CONTROL customer connect.	Any pressure in start tank vents.

h. Decrease pneumatic pressure to START TANK VENT VALVE CONTROL customer connect to zero.

i. Set a facility cutoff timer for 10-12 seconds.

CAUTION

Whenever an ignition-complete indication has been obtained, the ignition detection simulation circuit (electrical connector P54, pin M) must not be energized, since it will result in sending a redundant signal to the ECA ignition-complete circuit, which could result in damage to the ECA.

Operation	Result
j. Energize engine ignition and control power buses.	(1) Voltage from ignition and control voltage monitor circuits. Voltage must be within limits outlined in section II.
	(2) Engine-ready indication is obtained.
	(3) On engines incorporating MD338, MD380, or MD381 change; ignition-complete indication is obtained.

NOTE

On engines incorporating MD338 change, the ignition-complete indication is obtained through the dummy ignition detector probe. On engines incorporating MD380 or MD381 change, the ignition complete signal is obtained directly from the engine control power bus.

Operation	Result
k. On engines not incorporating MD338 change, energize ignition detection simulation circuit.	Ignition-complete indication is obtained.

NOTE

When testing engines installed in an SII stage, step l is not required, since a continuous signal is supplied to the mainstage enable circuit.

l. On engines installed in an SIVB stage, energize mainstage enable circuit. This must be done before engine start circuit is energized so that ignition phase timer redundancy can be verified.

1A. On engine incorporating MD366 or MD371 change, energize MRCV low EMR command.

m. Start recorders, and momentarily energize engine start circuit. Use recorder with a minimum speed capability of 10 inches a second. (See figure 3-50.)

Operation	Result
n. Approximately 0.7 second after mainstage control indication is obtained, energize mainstage OK bypass circuit.	Mainstage OK No. 1 and mainstage OK No. 2 indications are obtained. Engine sequences into a simulated mainstage condition.

nA. On engines incorporating MD366 or MD371 change, approximately 5 seconds after mainstage condition is obtained, deenergize MRCV low EMR command. Read MRCV potentiometer output voltage.

Operation	Result
nB. On engines incorporating MD366 or MD371 change, approximately 2 seconds after step nA, energize MRCV low EMR command. Read MRCV potentiometer output voltage.	On engines incorporating MD371 change, voltage change from step nA must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step nA must be between 0.6 and 1.0 vdc.
o. When facility timer expires, momentarily energize engine cutoff command circuit (if not sequenced automatically).	Engine cutoff occurs, and engine shutdown sequence is simulated.

Phase	Event (Indication)	Phase	Event (Indication)
Ignition	Helium control valve energized Ignition phase control valve energized Bleed valves closed ASI sparks on GG sparks on MFV opened ASI valve opened Ignition completed STDV control valve energized STDV opened MRCV opened MRCV low EMR command on	Mainstage (cont)	ASI sparks off GG sparks off MRCV closed/opened MRCV low EMR command on and off
Mainstage	Mainstage control valve energized MOV opened GG control valve opened OTBV closed STDV control valve deenergized STDV closed	Cutoff	Ignition phase control valve deenergized Mainstage control valve deenergized GG control valve closed ASI valve closed MFV valve closed MOV valve closed OTBV opened Helium control valve deenergized Bleed valves opened MRCV closed MRCV low EMR command off

Figure 3-50. Events Monitored During Engine Sequence Test

Operation	Result
oA. On engines incorporating MD366 or MD371 change, approximately 5 seconds after engine cutoff command, deenergize MRCV low EMR command. Read MRCV potentiometer output voltage.	On engines incorporating MD371 change, voltage change from step nB must be between 1.3 and 1.8 vdc. On engines incorporating MD366 change, voltage change from step nB must be between 0.6 and 1.0 vdc.
p. Deenergize mainstage OK bypass circuit.	Mainstage OK No. 1 and No. 2 indications drop out.
q. Fifteen seconds after engine cutoff, stop recorders.	Engine-ready indication is obtained after OTBV open indication is obtained.

r. If a facility cutoff lock-in circuit is used, energize cutoff reset circuit.

NOTE

The engine pneumatic control system must be cycled two complete times prior to running the sequence test to determine valve timing. This may be satisfied by running three sequence tests (step s), by performing the safety circuit tests with pressure in the pneumatic control system, or by operation of all timed valves in the components test mode.

- When performing sequence test at KSC (VAB hardwire test before rollout) or for verifying a replaced GG control valve on engines incorporating MD211 change or FSDV 558127-11, a minimum of 12 sequence tests must be run, to make sure the gas generator control valve does not exhibit a slowing trend.

s. Repeat steps l through r for additional sequence tests as required, waiting 5 minutes between each test.

NOTE

On engines incorporating MD380 or MD381 change, steps sA, sB, and sC provide a way to determine helium control deenergize timer operation.

sA. Restart recorders, and momentarily energize engine cutoff command circuit.

sB. After a minimum of 3 seconds, energize cutoff reset circuit.

sC. Stop recorders.

t. On engines not incorporating MD172 or MD214 change, determine corrected MOV opening time (second-stage motion) by multiplying recorded valve time by temperature correction factor specified in figure 3-51.

tA. On engines incorporating MD172 or MD214 change, if MOV actuator temperature is greater than 70° F, determine corrected MOV opening time (second-stage motion) by multiplying recorded valve time by temperature correction factor specified in figure 3-51.

tB. On engines incorporating MD172 or MD214 change, if MOV actuator temperature is less than 70° F, determine corrected MOV opening time (second-stage motion) by adding time change specified in figure 3-51A to recorded MOV opening time.

NOTE

On engines incorporating MD265 change, the MOV opening time (second-stage motion) is allowed to vary within a band of 50 milliseconds between sequence tests if the average time falls within the limits of figure 1-11.

u. On engines incorporating MD265 change, refer to Engine Log Book and obtain all MOV opening times (second-stage motion) since installation of control orifice. Using data obtained from Engine Log

Recorded Valve Temperature (°F)	Temperature Correction Factor	Recorded Valve Temperature (°F)	Temperature Correction Factor	Recorded Valve Temperature (°F)	Temperature Correction Factor
20	0.952	52	0.983	84	1.013
21	0.952	53	0.983	85	1.014
22	0.953	54	0.984	86	1.015
23	0.954	55	0.985	87	1.016
24	0.955	56	0.986	88	1.016
25	0.957	57	0.987	89	1.017
26	0.957	58	0.988	90	1.018
27	0.958	59	0.989	91	1.019
28	0.959	60	0.990	92	1.020
29	0.960	61	0.991	93	1.021
30	0.961	62	0.992	94	1.022
31	0.962	63	0.993	95	1.023
32	0.963	64	0.994	96	1.024
33	0.964	65	0.995	97	1.025
34	0.965	66	0.996	98	1.026
35	0.966	67	0.997	99	1.027
36	0.967	68	0.998	100	1.028
37	0.968	69	0.999	101	1.029
38	0.969	70	1.000	102	1.030
39	0.970	71	1.001	103	1.031
40	0.971	72	1.002	104	1.032
41	0.972	73	1.003	105	1.032
42	0.973	74	1.004	106	1.033
43	0.974	75	1.005	107	1.034
44	0.975	76	1.005	108	1.035
45	0.976	77	1.006	109	1.036
46	0.977	78	1.007	110	1.037
47	0.978	79	1.008	111	1.038
48	0.979	80	1.009	112	1.039
49	0.980	81	1.010	113	1.040
50	0.981	82	1.011	114	1.041
51	0.982	83	1.012	115	1.041

Figure 3-51. Temperature Correction Factor Chart

Recorded Valve Temperature (°F)	MOV Opening Time Change (Plus-Milli-seconds)	Recorded Valve Temperature (°F)	MOV Opening Time Change (Plus-Milli-seconds)	Recorded Valve Temperature (°F)	MOV Opening Time Change (Plus-Milli-seconds)
0	42.0	25	27.0	50	12.0
1	41.4	26	26.4	51	11.4
2	40.8	27	25.8	52	10.8
3	40.2	28	25.2	53	10.2
4	39.6	29	24.6	54	9.6
5	39.0	30	24.0	55	9.0
6	38.4	31	23.4	56	8.4
7	37.8	32	22.8	57	7.8
8	37.2	33	22.2	58	7.2
9	36.6	34	21.6	59	6.6
10	36.0	35	21.0	60	6.0
11	35.4	36	20.4	61	5.4
12	34.8	37	19.8	62	4.8
13	34.2	38	19.2	63	4.2
14	33.6	39	18.6	64	3.6
15	33.0	40	18.0	65	3.0
16	32.4	41	17.4	66	2.4
17	31.8	42	16.8	67	1.8
18	31.2	43	16.2	68	1.2
19	30.6	44	15.6	69	0.6
20	30.0	45	15.0	70	0.0
21	29.4	46	14.4		
22	28.8	47	13.8		
23	28.2	48	13.2		
24	27.6	49	12.6		

Figure 3-51A. MOV Opening Time Correction Value For Temperature (Applicable to Engines Incorporating MD172 or MD214 Change When MOV Temperature is Less Than 70° F)

Timer	Timing (Seconds)
STDV delay (Measure time between engine start signal and STDV control valve energization.)	0.640 ±0.030 1.000 ±0.040[a]
Ignition phase. (Measure time between STDV control valve on signal to mainstage control valve on signal.	0.450 ±0.030
Sparks deenergized. (Measure time from mainstage control valve on signal to ASI and GG sparks OK off.)	3.30 ±0.20
Helium control deenergize. (Measure time from cutoff on to helium control valve off signal.	1.00 ±0.11

(a) Engines incorporating MD205, MD380, or MD381 change.

Figure 3-52. Engine Sequence Control Timer Operating Values (Recorded)

Book and from sequence test being run, determine average valve time. This average time must be within envelope of figure 1-12 for engines incorporating MD265 change. The maximum allowable variation between any two sequence tests is 50 milliseconds.

v. Check all recordings to determine whether engine has functioned properly. Using recordings from last (third) sequence, see figure 1-11 for valve operating times and figure 3-52 for engine sequence control timer operating values. On engines incorporating MD380 or MD381 change, redundant timer traces are superimposed on spark monitor traces. (See figure 3-52A.) Figure 3-53 may be used as an aid when reading valve traces. If valve is to be reorificed, refer to R-3825-3 for procedure.

w. Make sure the four 28-volt output signals from Spark Monitor/Overspeed Cutoff Panel G1045 were energized approximately 0.5 second after engine start and remained on until approximately 3.3 seconds after mainstage control valve was energized. When Spark Monitor/Overspeed Cutoff Panel G1045 is not used, the requirements for the four spark monitor signals are outlined in R-3825-1.

Operation	Result
x. On engines not incorporating MD338, MD380, or MD381 change, deenergize igniton detection simulation circuit.	Ignition-complete indication drops out.

y. Deenergize circuit energized in step l.

z. Decrease pressure to engine helium tank to zero.

aa. Vent helium tank to zero by energizing engine helium control valve.

ab. After all pressure has vented from engine helium tank, deenergize engine helium control valve.

ac. Deenergize engine control and ignition power buses.

3.3.38 HELIUM-USAGE-TESTING ENGINE PNEUMATIC SYSTEM. During this test, record all actuations and deactuations of helium regulator and pressure level of each operation in Engine Log Book, Helium Regulator Assembly Operation Record. Refer to section II for checkout constraints before performing this test. Successful completion of the pneumatic system helium usage test and engine helium supply system pressure-decay test (paragraph 3.3.30) waives the requirement to remove brass plugs and leak-test the pneumatic system flange and weld joints. Helium-usage-testing the engine pneumatic system consists of performing procedures in paragraphs 3.3.38.1 and 3.3.38.2. These procedures may be done independently. Paragraph 3.3.38.2 may be performed before paragraph 3.3.38.1.

3.3.38.1 Helium Usage Sequence Testing.

a. Connect a supply of helium (refer to section II) capable of supplying a minimum of 1,400 psig to engine HELIUM TANK FILL customer connect.

NOTE

The monitoring system should contain a digital voltmeter capable of both visual and printout readings. The helium temperature transducer amplifier must have an electrical readout of 0-5 vdc, corresponding to a temperature range of -350° to +100° F.

b. Connect a monitoring system to engine connector P106, pins T, U, V, N, M, R, and Z, and connector P108, pins T, U, and M. Monitoring systems must be capable of monitoring the following FI parameters:

(1) Helium tank pressure (NN1); connector P106 pins, T, U, V, N, M, R, and Z.

(2) Helium tank gas temperature (NNT1); connector P108, pins T, U, and M.

WARNING

Failure to observe safety requirements of step c can result in injury to personnel.

c. Direct all personnel to stand behind adequate safety barriers or at a safe distance from engine while performing this test.

Operation	Result

CAUTION

Performing test with pressure in the start tank can damage the engine by causing dry-spinning of the fuel turbine.

Operation	Result
d. Apply 500 psia maximum pneumatic pressure to START TANK VENT VALVE CONTROL customer connect.	Any pressure in start tank vents.

e. Vent pressure to START TANK VENT VALVE CONTROL customer connect to zero.

CAUTION

Opening the MFV or the MOV with the stage propellant tanks pressurized and the pre-valves open or with more than 5 psig in the inlet ducts with the pre-valves closed can damage the engine oxidizer and fuel flowmeters by dry-spinning in excess of 60 seconds.

f. Verify that pressure in propellant inlet ducts is not greater than 5 psig and that prevalves are closed.

g. Slowly pressurize helium tank to 1,400-3,200 psig.

NOTE

If the helium tank is pressurized to less than 1,750 psig, the pressure remaining in the helium tank at the completion of the test must be a minimum of 450 psig. If the remaining pressure is less than 450 psig, the initial helium tank pressure must be increased to a minimum of 1,750 psig and the test repeated.

h. Before proceeding, check helium tank temperature periodically until helium tank gas temperature has stabilized (rate of change in temperature equal to or less than one degree per minute).

i. After helium tank gas temperature has stabilized, decrease pressure to HELIUM TANK FILL customer connect to zero. (Check valve isolates pressure in helium tank.)

j. Record helium tank pressure.

k. Set facility engine cutoff timer for 360 seconds.

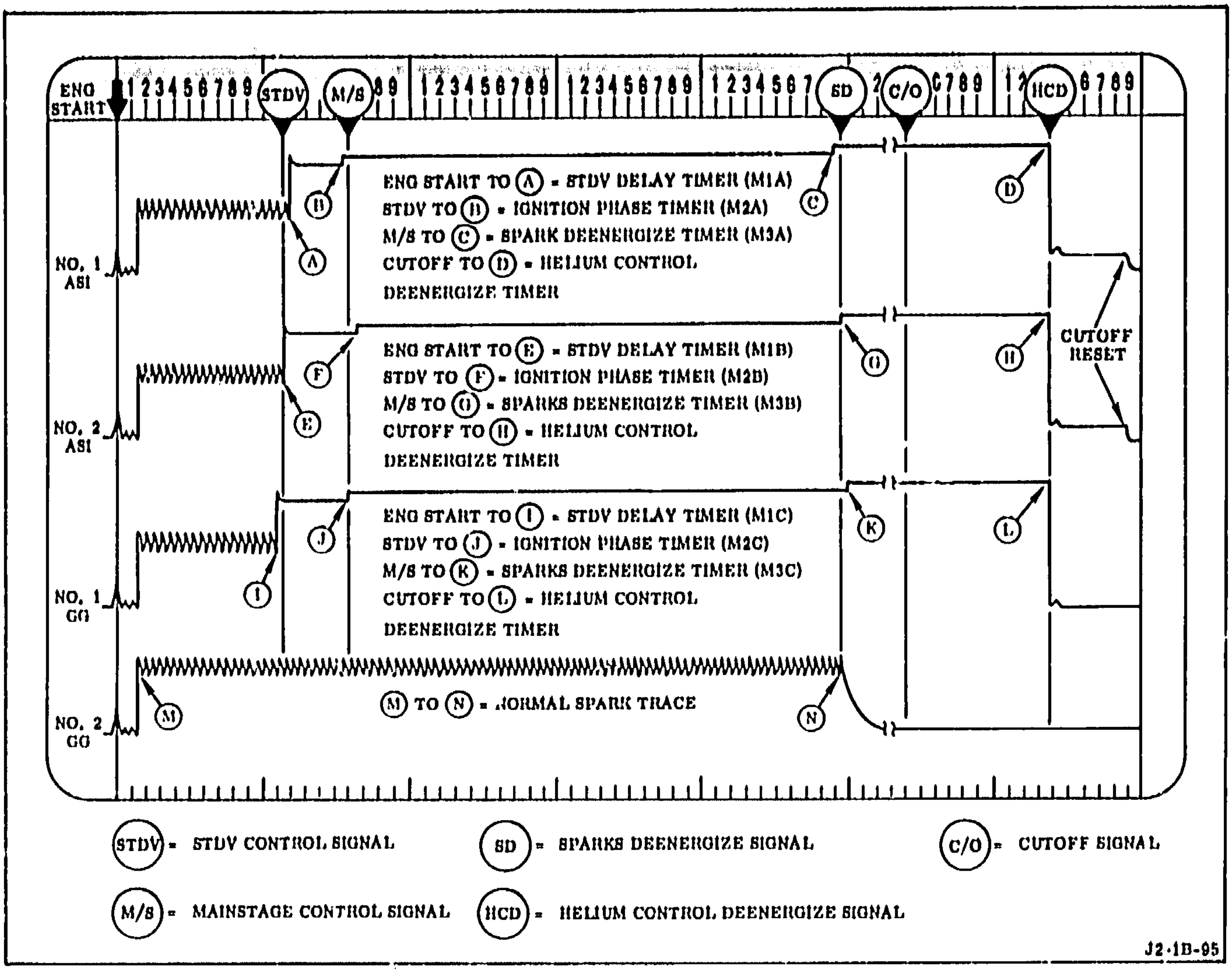


Figure 3-52A. Spark Monitor and ECA Timer Traces (Sheet 1 of 2)

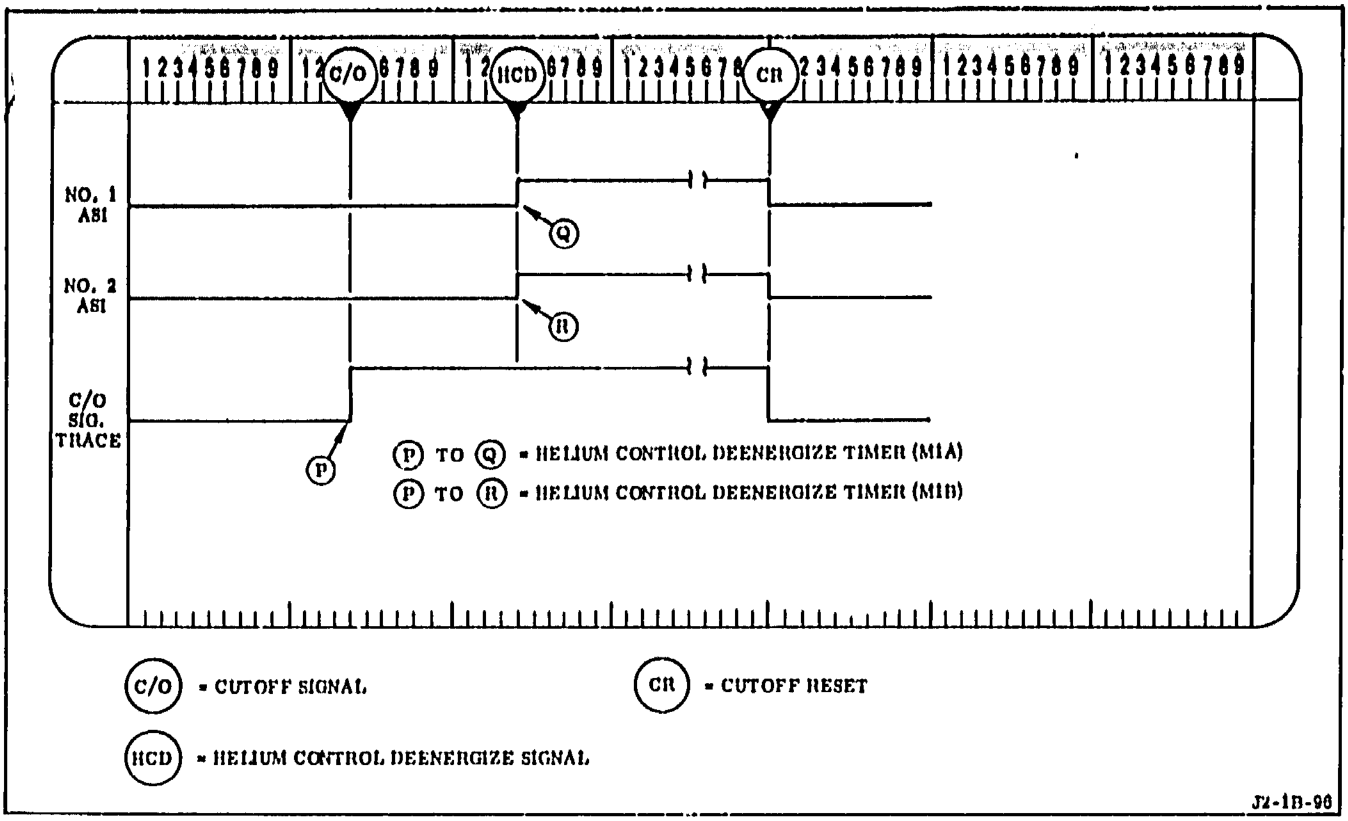


Figure 3-52A. Spark Monitor and ECA Timer Traces (Sheet 2 of 2)

CAUTION

Whenever an ignition-complete indication has been obtained, the ignition detection simulation circuit (electrical connector P54, pin M) must not be energized, since it will result in sending a redundant signal to the ECA ignition-complete circuit, which could result in damage to the ECA.

Operation	Result
l. Energize engine ignition and control power buses.	(1) Voltage from ignition and control voltage monitor circuits. (2) Engine-ready indication is obtained. (3) On engines incorporating MD338 change, ignition-complete indication is obtained.

NOTE

On engines incorporating MD338 change, the ignition-complete indication is obtained through the dummy ignition detector probe.

Operation	Result
m. On engines not incorporating MD338 change, energize ignition detection simulation circuit.	Ignition-complete indication is obtained.

mA. On engines incorporating MD366 or MD371 change, energize MRCV low EMR command.

NOTE

When testing engines installed in an SII stage, step n is not required, since a continuous signal is supplied to the mainstage enable circuit.

n. On engines installed in an SIVB stage, energize mainstage enable circuit.

o. Momentarily energize engine start circuit.

oA. On engines incorporating MD371 change, approximately 5 seconds after mainstage condition is obtained, deenergize MRCV low EMR command.

NOTE

When cycling the MRCV in step oB or oC, use time that will duplicate the activity that will be required of the MRCV during flight. On restart mission engines, use time that will be required of the MRCV during second burn. If flight time (mission) is not known, use times specified in step oB or oC.

oB. On engines incorporating MD371 change, approximately 320 seconds after mainstage condition is obtained, energize MRCV low EMR command.

oC. On engines incorporating MD366 change, approximately 115 seconds after mainstage condition is obtained, deenergize MRCV low EMR command.

Operation	Result
p. Approximately 0.7 second after mainstage control indication is obtained, energize mainstage OK bypass circuit.	(1) Mainstage OK No. 1 and No. 2 indications are obtained. (2) Engine sequences into a simulated mainstage condition.
q. When facility timer expires (360 seconds), momentarily energize engine cutoff command circuit (if not sequenced automatically)	Engine cutoff occurs, and engine shutdown sequence is simulated.
r. Deenergize mainstage OK bypass circuit.	(1) Mainstage OK No. 1 and mainstage OK No. 2 indications drop out. (2) Engine-ready indication is obtained after OTBV opens.
s. On engines not incorporating MD338 change, deenergize ignition detection simulation circuit.	Ignition-complete indication drops out.

t. Deenergize circuit energized in step n.

u. If a facility cutoff lock-in circuit is utilized, energize cutoff reset circuit.

uA. On engines incorporating MD366 or MD371 change, approximately 5 seconds after engine cutoff command, deenergize MRCV low EMR command.

v. Obtain and record helium tank pressure reading after helium control valve deenergizes (approximately one second after engine cutoff signal).

w. If sequence test duration was 360 ±4 seconds, find helium usage by subtracting final pressure reading (step v) from initial pressure reading (step j). Record as engine helium usage.

x. If sequence test duration varied by more than 4 seconds from 360 seconds, calculate helium usage as follows:

$$\text{Helium usage} = \Delta P_1 + \frac{360 \ \Delta P_2}{t} + \Delta P_3$$

where

ΔP_1 = pressure drop from engine start to engine start plus 2 seconds (psi)

ΔP_2 = pressure drop from engine start plus 2 seconds to engine cutoff (psi)

ΔP_3 = pressure drop from engine cutoff plus one second (psi)

t = time from engine start to engine cutoff (seconds) (must be 360 ±30 seconds)

y. Determine maximum allowable pressure difference (ΔP) using the following equation:

$$\Delta P = 0.12P + 870 + A$$

where

ΔP = maximum allowable pressure difference in psi

P = initial tank pressure (1,400-3,200 psig)

A = value for adjusting maximum calculated pressure difference for oxidizer turbopump intermediate seal purge flow. (Add 9 psi for each 100 scim of purge flow in excess of 4,400 scim, or subtract 9 psi for each 100 scim of purge flow less than 4,400 scim.)

yA. Compare actual engine helium usage obtained in step w or x with maximum allowable pressure difference value determined in step y. Actual engine helium usage must be equal to or less than maximum allowable pressure difference value. If helium usage is unacceptable, perform pneumatic control system leak test (paragraph 3.3.29) to determine source of leakage. If pneumatic system leak test does not indicate source of excessive helium usage, contact Engine Contractor for disposition.

z. Vent helium tank to zero by energizing engine helium control valve.

aa. After all pressure has vented from helium tank, deenergize engine helium control valve.

ab. Deenergize engine control and ignition power buses.

3.3.38.2 Pneumatic Accumulator System Test. The MD333 change must be incorporated before performing this test.

a. Remove vent port check valve from boss in MFV closing control line.

b. Connect a monitoring system that incorporates a vent valve and is capable of measuring 0-600 psig to boss in MFV closing control line. Line length from engine to monitoring system must not exceed 30 feet or 1/4-inch line. This test may exceed personnel safety limits. In accordance with site safety standards, position monitor gage and vent valve far enough from engine to protect personnel from danger.

c. Remove protective closures from the following:

(1) Thrust chamber exit (or one desiccant access cover from exit closure).

(2) Oxidizer turbopump primary seal drain line (stage overboard drain line on engines incorporating MD301, MD302, MD322, or MD323 change).

(3) Oxidizer turbopump intermediate seal purge check-valve vent.

CAUTION

Opening the MFV or the MOV with the stage propellant tanks pressurized and the pre-valves open or with more than 5 psig in the inlet ducts with the pre-valves closed can damage the engine oxidizer and fuel flowmeters by dry-spinning in excess of 60 seconds.

d. Verify that pressure in the inlet ducts is not greater than 5 psig and that the pre-valves are closed.

e. Energize helium and mainstage control valves.

f. Pressurize engine helium tank to 600-3,200 psig.

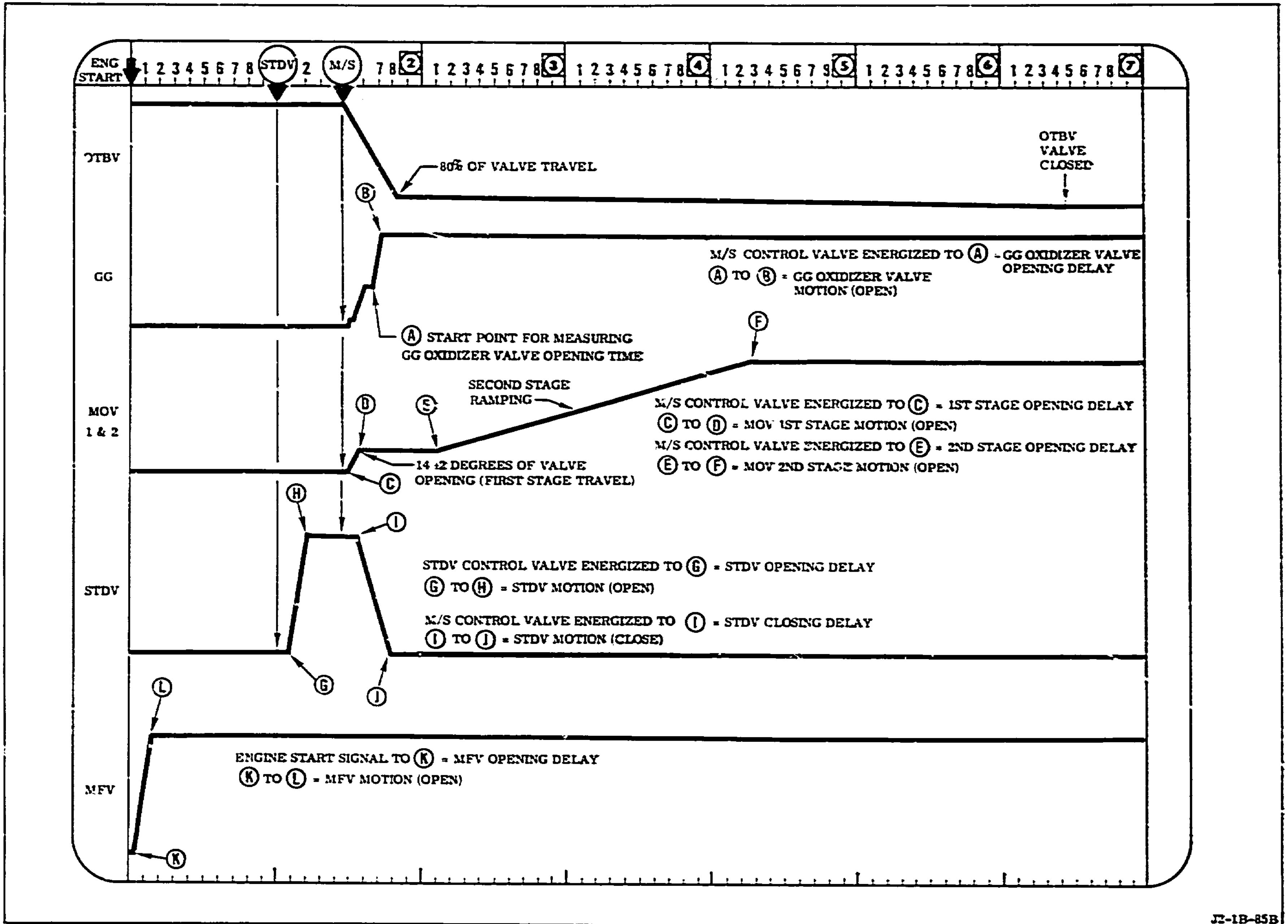


Figure 3-53. Determining Engine Valve Times (Typical Valve Traces) (Sheet 1 of 2)

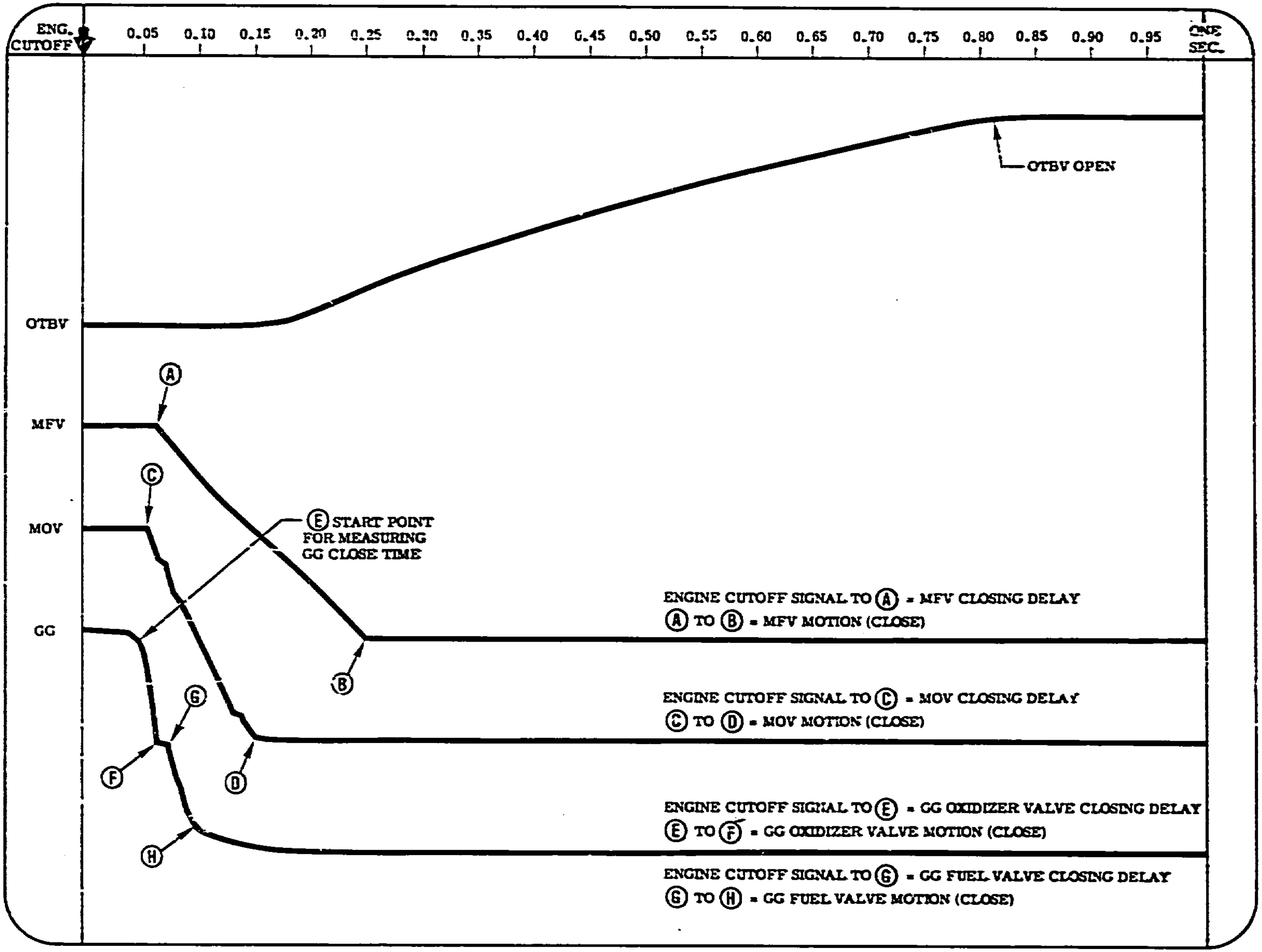


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Figure 3-53. Determining Engine Valve Times (Typical Valve Traces) (Sheet 2 of 2)

g. Note pressure on monitor gage connected in step b, convert to absolute pressure, and record as pressure P1.

h. Energize ignition-phase control valve.

i. Deenergize helium control valve; then immediately deenergize ignition-phase control valve. Note pressure on monitor gage, convert to absolute pressure, and record as pressure P2.

j. Energize helium and ignition-phase control valves.

k. Deenergize helium control valve, wait 6 minutes (+5, -0 seconds), then deenergize ignition-phase control valve. Note pressure on monitor gage, convert to absolute pressure, and record as pressure P3.

l. Using the following formula, determine final accumulator system pressure:

$$P3 \times \frac{P1}{P2} = \text{final accumulator system pressure}$$
(Value must be a minimum of 315 psia.)

m. Decrease pressure to helium tank to zero.

n. Open vent valve in monitor system connected in step b.

o. Deenergize mainstage control valve.

p. Energize helium control valve.

q. After all pressure has vented, deenergize helium control valve.

r. Disconnect monitor system from boss in MFV closing control line, and reinstall vent port check valve. (Refer to R-3825-3.)

s. Reinstall protective closures removed in step c.

3.3.30 PREPARING VIBRATION SAFETY CUTOFF SET. The engine must have VSC protection during static testing. The use of 3 VSC units (ternary system) increases VSC system reliability and decreases the possibility of an engine cutoff caused by VSC system malfunction. To prepare the set for operation, a preoperation cutoff test and a preoperation tap test of the vibration cutoff set must be performed. The cutoff test verifies the specific settings at which the VSC operates during an engine ground test. During the cutoff test, if the accelerometer attenuator dial setting and the sensitivity dial setting variations become greater than 5 percent of the established recorded settings, the test must be terminated and the VSC unit must be removed and replaced with a calibrated unit. The defective unit must be assigned for repair.

a. Install accelerometer in location shown in figure 3-54. On engines incorporating MD247 change, a fourth accelerometer may be installed to provide a capability for FI measurement and to permit the use of a ternary VSC system during stage static test. Torque accelerometers to 18 ±2 in-lb.

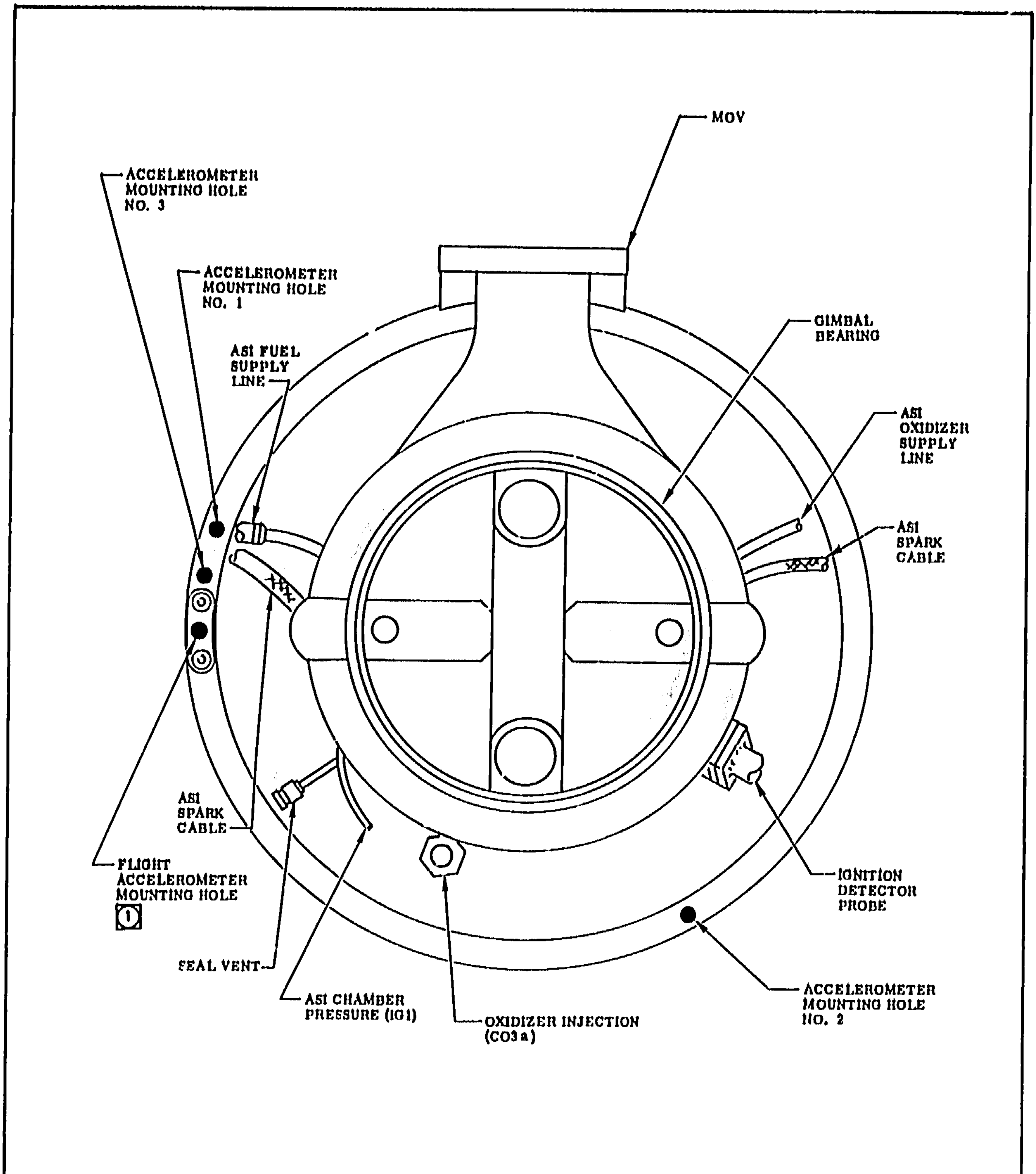


Figure 3-54. Accelerometer Mounting Locations

CAUTION

Accelerometer torque must not exceed 20 in-lb, to prevent the accelerometer from being twisted off.

- The accelerometer cable must be disconnected (if attached) before installing the accelerometer to prevent possible twisting.
- The accelerometer is a sensitive instrument and can be damaged by rough treatment, such as dropping, sharp blows, over-torquing, or pulling on the accelerometer cable.

b. Connect and secure accelerometer cable. Do not secure accelerometer cables to cryogenic lines or surfaces. Make sure cable is not twisted or damaged.

NOTE

An improperly secured accelerometer cable may cause "hammering" signals to be transferred to the VSC system.

c. Position isolation amplifiers and cutoff-unit power switches to ON and allow 15 minutes for temperature stabilization.

Operation	Result
d. Position cutoff unit DISABLE-ARM switch to ARM.	ARM light comes on.

e. Disconnect accelerometer cable from isolator amplifier input connector.

f. Connect signal generator and an ac voltmeter to isolator amplifier input connector. Set signal generator output frequency at 2,000 ±20 Hz and output voltage to a value less than 0.25 volt rms.

NOTE

The ac voltmeter must have a minimum range of 0.10 to 3.00 volts rms, a minimum accuracy of 2 percent of reading, and a minimum input impedance of one megohm.

g. Slowly increase signal generator output voltage until CUTOFF light comes on and ARM light goes off on VIBRATION SAFETY CUTOFF panel.

h. Voltage reading must agree within 5 percent with value of V_1 recorded on VSC unit check form. If voltage reading is not as required, recalibrate VSC system as outlined in R-3825-5.

NOTE

The value of V_1 was calculated and recorded during installation and checkout of the VSC unit as outlined in R-3825-5. The recommended settings are: 150g rms cutoff level, 70 milliseconds delay (required dwell) time, and required 350 milliseconds storage accumulated time.

i. Make sure no cutoff signal was supplied from VSC unit to test stand electrical system. Event recorder must indicate cutoff.

j. Decrease signal generator output voltage to a value less than 0.25 volt rms.

Operation	Result
k. Press VSC unit RESET switch.	CUTOFF light must go off and ARM light must come on. EVENT recorder must not indicate cutoff.

l. Deenergize signal generator and disconnect signal generator and ac voltmeter from isolator amplifier.

m. Repeat steps d through l on remaining 2 VSC systems. Results must be the same.

n. Connect a signal generator to isolator amplifier input connector of VSC units No. 1 and No. 2 using a T-connector.

o. Make sure signal generator output voltage is set to a value below 0.25 volt rms.

Operation	Result
p. Slowly increase signal generator output voltage until an engine cutoff signal is received by test stand electrical system.	CUTOFF light must come on and ARM light must go off on both VIBRATION SAFETY CUTOFF panels. Both event recorders must indicate cutoff.

q. Decrease signal generator output voltage to a value less than 0.25 volt rms.

r. Momentarily actuate test stand VSC reset circuit.	Both CUTOFF lights must go off and both ARM lights must come on. Event recorders must not indicate cutoff.

s. Deenergize signal generator and disconnect from VSC units No. 1 and No. 2.

t. Connect signal generator to isolator amplifier input connector of VSC units No. 1 and No. 3 using T-connector.

u. Repeat steps o through r. Results must be the same.

v. Deenergize signal generator and disconnect from VSC units No. 1 and No. 3.

w. Connect signal generator to isolator amplifier input connector of VSC units No. 2 and No. 3 using a T-connector.

x. Repeat steps o through r. Results must be the same.

y. Deenergize signal generator and disconnect from VSC units No. 2 and No. 3.

z. Reconnect accelerometer cables. On each VSC system, momentarily press cutoff unit RESET switch.	CUTOFF light must be off and ARM light must be on.

NOTE

Steps aa through ad outline a preoperation tap test. Perform a tap test on each VSC unit.

aa. Connect a set of headphones to VSC unit.

Operation	Result
ab. Using a brass hammer, tap gently on thrust chamber dome.	An audible signal must be received in headphones.

NOTE

The headphone attenuator control on the VSC unit may require adjustment to provide an audible signal in headphones.

•The VSC set is ready for operation at the conclusion of the tap test. The tap test must be performed before each static test along with a visual verification of VSC control dial settings. The verniers of the timing and cutoff adjustment controls must be within 5 percent of the original settings.

ac. Visually verify VSC control dial settings. Delay time control dial must be set at 458. Storage time control dial must be set at 625.

ad. If VSC unit is not to be used immediately, position power switches on isolator amplifier and cutoff unit to OFF.	ARM light must go off.

3.3.40 <u>PREPARING GAS GENERATOR HIGH-LOW TEMPERATURE CUTOFF PANEL.</u> This task consists of performing a preoperation calibration and a system checkout test that must be performed before the firing test. Panel calibration is required whenever a component or the entire panel is changed.

a. Calibration-test (as outlined in R-3825-5) using the required settings shown in figure 3-55.

Adjustment Identification	Required Setting	Remarks
Timer: Z2 or 0.05 to 1.0	0.5 ±0.05 second	If timers are not required, timers must be adjusted as outlined in R-3825-5.
	0.80 ±0.08 second	For altitude testing
Timer: Z3 or 0.4 to 8.0	3.5 ±0.35 second	If timers are not required, timers must be adjusted as outlined in R-3825-5.
Limit switch: Z4, 150° to 400°, or 200° to 400°	180° ±30° F 250° ±100° F	On panels incorporating MD2 change
Limit switch: Z5 or 1300° to 1700°	1,450° ±50° F	--
Limit switch: Z6 or 1700° to 2200°	2,000° ±100° F	--
Variable resistor: R11	800° ±50° F	Prevents thermocouple open signal with thermocouple open after 3.5 seconds from mainstage control signal. Always active on panels incorporating MD4 change.
Amplifier output variable resistor: R10	Depends on facility instrumentation requirements.	On panels incorporating MD1 change
Amplifier zero: Z1	As near zero as thermocouple line length permits.	For panel adjustment procedure refer to R-3825-5.
Amplifier gain adjust: Z1	600 on panels incorporating MD2 change	For panel adjustment procedure refer to R-3825-5.
	500 on panels not incorporating MD2 change	

Figure 3-55. Gas Generator High-Low Temperature Cutoff Panel Settings

b. Connect facility drag-in cable to GG overtemperature transducer. Torque connector to 30-40 in-lb, and safetywire.

NOTE

The GG cable must be provisioned with thermocouple connector RD414-1013-1002, or equivalent, to mate with transducer. The Chromel and Alumel wire leads should be brazed to pins on the connector. (Refer to R-3825-1 for brazing requirements.)

c. Determine engine and GG high-low temperature panel interconnection as follows:

(1) Apply engine ground power.

(2) Make sure engine cutoff is reset.

(3) Make sure helium tank pressure is zero.

(4) Energize engine mainstage control valve by accomplishing an engine sequence test with cutoff from GG high-low cutoff panel enabled or by applying a signal at components test input (connector P54-P).

(5) Engine cutoff must be obtained at connectors P51-Y or P54-V 0.5 ±0.05 second after mainstage control signal (GG undertemperature cutoff).

(6) Turn off ground power and secure engine.

d. Temperature monitor connected to connectors J1-L (+) and J1-M (-) must indicate temperature at engine hot-gas thermocouple (instrumentation port TGT1a). Compare temperature indication with estimated engine temperature. Temperature monitor indication may be compared with temperature indicated by FI temperature transducer at instrumentation port TGT1 if steady-state temperature conditions exist in engine fuel turbine inlet. Indications must be approximately the same.

3.3.41 PREPARING SPARK MONITOR/OVERSPEED CUTOFF PANEL. This task consists of performing a preoperation test on the spark exciter monitor and the overspeed cutoff unit. The spark exciter monitor preoperation test is performed during the engine control system component test mode. Actuate spark controls individually and obtain spark OK signals. (Refer to R-3825-5 for calibration requirements.)

a. Energize panel with 28 vdc power.

b. Using a signal generator, apply frequency signals (0.75 ±0.25 volt peak) to a facility connect point corresponding to the pins of connector J4, as shown in figure 3-56.

c. Verify that engine facility firing equipment is reset from cutoff.

Operation	Result
d. Slowly increase frequency of signal generator until engine cutoff signal is obtained.	Cutoff signal must be within frequency limits of figure 3-56.

Signal Applied to J4 pins:	Test	Frequency (cps for Cutoff)	Turbopump RMP (Maximum)	Engine Effectivity
E, F	Fuel turbopump speed	5,680 ±50	28,400 ±250	J-2036-1 through J-2059
E, F	Fuel turbopump speed	5,800 ±50	29,000 ±250	J-2060 and subsequent
A, B	Oxidizer turbopump speed	1,900 ±20	9,500 ±100	All engines

Figure 3-56. Spark Monitor/Overspeed Cutoff Panel Frequency Signals

NOTE

It may be necessary to adjust the panel overspeed cutoff frequency (Hz). (Refer to R-3825-5.)

e. Decrease signal generator to a frequency less than that required to obtain cutoff in step d. Reset cutoff.

f. Using an ohmmeter, verify at facility connect points that points corresponding to connector J4, pins E, F, A, and B, are greater than 100,000 ohms from facility ground.

NOTE

On panels incorporating MD1 change, facility instrumentation connected to connector J5 may be calibrated while frequencies are applied for the cutoff test.

3.4 STORAGE AND SHIPMENT PREPARATION.

WARNING

Engine Handler G4064 must be operated by authorized personnel trained in the use of the equipment.

3.4.1 The engine must be stored on Engine Handler G4064 when possible. If sufficient handlers are not available, the engine may be stored in the vertical position, as outlined in paragraph 3.4.3.

3.4.2 STORING ENGINE ON HANDLER.

a. If anticipated storage period exceeds 7 days, loosen, invert, and refasten engine handler deck sections that cover storage compartments.

b. Secure 640 units of bagged, activated desiccant under elastic holding straps. (Refer to section II.)

NOTE

Covers and closures containing desiccant must indicate the amount and date of desiccation.

c. Make sure that engine covers and closures are installed and that closures requiring desiccant contain the amount of desiccant indicated on the closure.

d. Mount engine on Engine Handler G4064. (Refer to R-3825-3.)

e. Place engine record forms in receptacle in engine handler base.

f. Disengage captive bolts that hold hinged engine cover retaining strips around periphery of engine handler base.

g. Install engine cover. (Refer to R-3825-3.)

3.4.3 STORING UNINSTALLED ENGINE IN VERTICAL POSITION. The engine must be stored in the vertical position only in a secure, covered building with a clean, level floor. Lifting or moving the engine must be done with an overhead crane and slings specified in R-3825-3.

NOTE

Covers and closures containing desiccant must indicate the amount and date of desiccation.

a. Make sure that engine covers and closures are installed and that closures requiring desiccant contain the amount of desiccant indicated on closure.

b. Remove engine from engine handler or vertical installer. (Refer to R-3825-3.)

c. Slowly lower engine to floor.

CAUTION

Contacting or bumping engine components with the engine sling can result in extensive damage to the engine.

d. Disconnect and remove engine forward sling from engine by supporting sling and disconnecting from oxidizer side of engine, then from fuel side of engine. Use extreme care to prevent sling from bumping engine components. Remove sling from hoist.

e. On engines incorporating MD338 change, install dummy ignition detector probe and bracket on flange of hydrogen tank pressurization line with 2 bolts, washers, and nuts. Torque nuts to 30-40 in-lb.

f. Remove engine handling adapters RX-20899 and RX-20900 from fuel and oxidizer sides of thrust chamber.

g. Cover engine to protect it from dust, dirt, and foreign particles.

3.4.4 SHIPPING UNINSTALLED ENGINE.

a. If anticipated transit storage period exceeds 7 days, loosen, invert, and refasten engine handler deck sections that cover storage compartments.

b. Secure 640 units of bagged, activated desiccant (MIL-D-3464, Type II) under elastic holding straps.

NOTE

Covers and closures containing desiccant must indicate the amount and date of desiccation.

c. Make sure that engine covers and closures are installed and that closures requiring desiccant contain the amount of desiccant indicated on the closure.

d. Mount engine on Engine Handler G4064. (Refer to R-3825-3.)

e. Place engine record forms in receptacle in engine handler base.

f. Disengage captive bolts that hold hinged engine cover retaining strips around periphery of engine handler base.

g. Remove engine cover and cover sling from handler storage compartment.

h. Assemble and attach cover sling to overhead hoist and to engine cover. Hoist and arrange cover over mounted engine assembly so that padding built into cover coincides with engine handler projections.

i. Position soft bead of engine cover so that it is held in position evenly and firmly by hinged engine cover retaining strips. Secure strips with captive bolts. Torque bolts to 20-26 in-lb.

j. Safetywire captive bolts at each end and in center of each retaining strip. Attach a lead seal at end of each lockwire.

k. Place engine assembly, mounted on Engine Handler G4064, into an acceptable transporting vehicle (truck or aircraft). Secure handler to transporting vehicle by utilizing tiedown points on handler. (Refer to R-3825-3.)

3.4.5 STORING AND SHIPPING STAGE-INSTALLED ENGINE. All information pertaining to storing or shipping a stage-installed engine is outlined in section I.

3.5 SERVICING.

3.5.1 CONNECTING OXIDIZER DOME PURGE CO3a.

a. Remove plug from instrumentation port CO3a.

b. Install oxidizer dome purge diffuser 210655 from kit 9019975 using seal 404659 or 408767.

c. Torque diffuser to 40-55 in-lb and safetywire to port CO3a boss.

CAUTION

Failure to hold the purge diffuser with a wrench while tightening or torquing the purge supply line fitting or instrumentation plugs can result in damage to the purge diffuser or instrumentation port CO3a boss.

d. Connect gaseous nitrogen supply line to diffuser. While holding diffuser with a wrench, torque supply line to 135-165 in-lb. Gaseous nitrogen supply system must incorporate a check valve in line within 6 inches of purge diffuser inlet.

e. Install a thermocouple capable of measuring 100° to 200° F in diffuser. The thermocouple used to measure the purge gas temperature must have a 0.12-inch diameter, or greater, to prevent excessive insertion into the boss and blockage of the purge gas.

f. Install plugs AN814-4CL in unused instrumentation ports of purge diffuser, using seals RE261-3004-0004. Torque plugs to 70-80 in-lb, and safetywire.

3.5.2 PURGING ENGINE START TANK.

a. Supply gaseous hydrogen or helium at 50° to 200° F to START TANK INITIAL FILL customer connect. Pressurize start tank to 75-150 psia.

b. Shut off hydrogen or helium supply and vent start tank to zero by supplying ambient-temperature helium at 390-550 psia to START TANK VENT VALVE CONTROL customer connect.

c. Vent pneumatic pressure to close start tank vent-and-relief valve.

d. Repeat steps a and b twice. Vent pneumatic pressure to close start tank vent-and-relief valve.

3.5.3 FILLING ENGINE HELIUM TANK.

a. Make sure thrust chamber exit closure is removed.

b. Supply ambient or chilled helium to engine HELIUM TANK FILL customer connect from a regulated supply of helium (refer to section II).

c. Pressurize engine helium tank to 2,800-3,200 psia and maintain to desired pressure. (Refer to paragraph 3.5.6 or 3.5.7 for conditioning requirements.)

d. If helium tank pressure exceeds 3,450 psia, immediately turn off helium supply and decrease pressure by energizing engine helium tank emergency vent valve.

NOTE

When the helium tank must be vented during prelaunch operations or at any time subsequence to the prelaunch helium supply system pressure-decay test, the helium tank must be vented by the engine helium control valve. The engine helium tank emergency vent valve may be used to vent the tank during emergency situations only.

3.5.4 FILLING ENGINE START TANK. The start tank must be purged before filling and after removal and/or replacement of instrumentation that allows the entry of air into the tank. (Refer to paragraph 3.5.2.) The engine helium tank must be filled (paragraph 3.5.3) before starting this procedure. If, during start tank charging and conditioning, it becomes apparent that manual or remote venting of the start tank is not being done (indicated by a tank pressure in excess of 1,400 psia), immediately perform emergency procedures of paragraph 3.5.5 to prevent excessive pressure buildup and possible damage to engine or stage.

a. Supply helium (refer to section II) at 390-550 psia to START TANK VENT VALVE CONTROL customer connect. Start tank vent-and-relief valve opens.

b. Supply cold gaseous hydrogen (refer to section II) to START TANK INITIAL FILL customer connect. Continue hydrogen flow until start tank temperature becomes semistabilized at conditions selected. See figure 3-57 or 3-58 for conditioning requirements.

NOTE

On SIVB/SV-stage engines with no inflight helium tank replenishing capability, the start tank temperature at engine start must be within 20° F of helium tank temperature. To meet this 20° F differential temperature requirement, perform step c.

c. On SIVB/SV-stage engines, supply cold hydrogen (at or below -170° F) to START TANK INITIAL FILL customer connect at pressures between 900 and 1,400 psia. Maintain this start tank condition for 10 minutes with helium tank pressure maintained at 3,000 ±200 psia.

d. When start tank has chilled to specified limits, vent pneumatic pressure applied to START TANK VENT VALVE CONTROL customer connect; start tank vent-and-relief valve closes. Pressurize start tank to requirements of figure 3-57 or 3-58.

Procedure	Fuel Lead Time (Seconds) 1.0 ±0.04	3.0 ±0.1	8.0 ±0.24	Remarks
THRUST CHAMBER CONDITIONING				
Equilibrium helium flow-rate through thrust chamber bell	10-25 lb/min	10-25 lb/min	N/A	
Thrust chamber purge line pressure at customer connect panel	1,000 psia maximum	1,000 psia maximum	N/A	
Thrust chamber purge line temperature at customer connect panel	-420° to -300° F	-420° to -300° F	N/A	
Duration of helium thrust chamber conditioning	7-1/2 to 30 minutes	7-1/2 to 30 minutes	N/A	
Thrust chamber jacket temperature at engine start. (Use a or b.)	-300° to -150° F	-300° to -80° F	Engine ambient	When using an 8-second fuel lead, the fuel injection temperature sensor must be used to sense proper thrust chamber conditioning.
Maximum hold-time between helium off and engine start	5 seconds at -150° F 30 seconds at -200° F 60 seconds at -250° F	5 seconds at -150° F 30 seconds at -200° F 60 seconds at -250° F	N/A N/A N/A	Hold-time is predicated on absence of diffuser water flow and thrust chamber exit igniter ignition until 5 seconds before engine start. Increased water flow and igniter ignition times will result in decreased allowable hold-times.
FUEL SYSTEM CONDITIONING				The engine fuel-system fuel suction line, fuel pump, main high-pressure fuel duct to MFV, and GG fuel line to fuel bleed line connection will be conditioned.

Figure 3-57. Engine Conditioning for Static Test (Sheet 1 of 3)

Procedure	Fuel Lead Time (Seconds)			Remarks
	1.0 ±0.04	3.0 ±0.1	8.0 ±0.24	
FUEL SYSTEM CONDITIONING (continued)				
Propellant in engine system before start	1/2 hour minimum	1/2 hour minimum	5 minutes minimum	
Duration of fuel circulation:				
Total	5 minutes minimum	5 minutes minimum	5 minutes minimum	
With subcooled liquid at engine inlet before engine start	3 minutes minimum	3 minutes minimum	3 minutes minimum	
Circulation flowrate	0.9 to 2.0 lb/sec	0.9 to 2.0 lb/sec	0.9 to 2.0 lb/sec	Refer to R-3825-1 for information on bleed flow during engine conditioning.
Engine inlet propellant condition at engine start	See figures 2-7 and 2-9.	See figures 2-7 and 2-9.	See figures 2-7 and 2-9.	
OXIDIZER SYSTEM CONDITIONING				The engine oxidizer-system oxidizer suction line, oxidizer pump, main high-pressure oxidizer duct to MOV, and GG oxidizer line to oxidizer bleed line connection will be conditioned.
Propellant in engine system before start	2 hours minimum	1 hour minimum	5 minutes minimum	
Duration of oxidizer circulation:				
Total	120 minutes minimum	5 minutes minimum	5 minutes minimum	
With subcooled liquid at engine inlet before engine start	3 minutes minimum	3 minutes minimum	3 minutes minimum	

Figure 3-57. Engine Conditioning for Static Test (Sheet 2 of 3)

Procedure	Fuel Lead Time (Seconds) 1.0 ±0.04	3.0 ±0.1	8.0 ±0.24	Remarks
<u>OXIDIZER SYSTEM CONDITIONING (continued)</u>				
Circulation flowrate	Oxidizer circulation flowrate and duration must be sufficient to obtain temperature of 3° F subcooled or colder (figure 2-8), measured at instrumentation port POT3, in oxidizer high-pressure duct before engine start.			Refer to R-3825-1 for information on bleed flow during engine conditioning.
Engine inlet propellant condition at engine start	See figures 2-5 and 2-7.	See figures 2-5 and 2-7.	See figures 2-5 and 2-7.	
<u>START TANK CONDITIONING</u>				
Condition at engine start:				
Hydrogen pressure and temperature	See figure 2-11.	See figure 2-11.	See figure 2-11.	Refer to paragraph 3.5.4 for tank fill procedure. 1,325 ±75 psia and -170° ±30° F must be used at initial start for restart application.
<u>HELIUM TANK CONDITIONING</u>				
Condition at engine start:				
Helium pressure	2,800-3,450 psia	2,800-3,450 psia	2,800-3,450 psia	Refer to paragraph 3.5.3 for tank fill procedure.
Helium temperature	(a)	(a)	(a)	

(a) Helium temperature must be within same temperature range as selected hydrogen start tank conditioning.

Figure 3-57. Engine Conditioning for Static Test (Sheet 3 of 3)

Procedure	Fuel Lead Time (Seconds) 1.0 ±0.04	3.0 ±0.1	8.0 ±0.24	Remarks
<u>THRUST CHAMBER CONDITIONING</u>				
Equilibrium helium flow-rate through thrust chamber bell	10-25 lb/min	10-25 lb/min	N/A	
Thrust chamber purge line pressure at customer connect panel	1,000 psia maximum	1,000 psia maximum	N/A	
Thrust chamber purge line temperature at customer connect panel	-420° to -300° F	-420° to -300° F	N/A	
Duration of helium thrust chamber conditioning	8-20 minutes	8-20 minutes	N/A	
Thrust chamber jacket temperature at engine start. (Use a or b.)	-300° to -150° F	-300° to -80° F	Engine ambient	When using an 8-second fuel lead, the fuel injection temperature sensor must be used to sense proper thrust chamber conditioning.
Maximum hold-time between helium off and engine start	5 seconds at -150° F 30 seconds at -200° F 60 seconds at -250° F	5 seconds at -150° F 30 seconds at -200° F 60 seconds at -250° F	N/A N/A N/A	Hold-time is predicated on absence of diffuser water flow and thrust chamber exit igniter ignition until 5 seconds before engine start. Increased water flow and ignitor ignition times will result in decreased allowable hold-times.
<u>FUEL SYSTEM CONDITIONING</u>				The engine fuel-system fuel suction line, fuel pump, main high-pressure fuel duct to MFV, and GG fuel line to fuel bleed line connection will be conditioned.

Figure 3-57. Engine Conditioning for Static Test (Sheet 1 of 3)

Procedure	SIB Vehicle	SV Vehicle			Remarks
	SIVB Stage	SII Stage	SIVB-Stage First Start	SIVB-Stage Second Start	
ENGINE SYSTEM PURGES	See figure 2-4.	See figure 2-4.	See figure 2-4.	See figure 2-4.	
THRUST CHAMBER CONDITIONING					
Equilibrium helium flowrate through thrust chamber bell	10-25 lb/minute	10-25 lb/minute	10-25 lb/minute	N/A	
Thrust chamber purge line pressure at customer connect panel	1,000 psia maximum	1,000 psia maximum	1,000 psia maximum	N/A	
Thrust chamber purge line temperature at customer connect panel	-420° to -300° F	-420° to -300° F	-420° to -300° F	N/A	
Duration of thrust chamber conditioning	7-1/2 to 30 minutes[(a)]	7-1/2 to 30 minutes[(a)]	7-1/2 to 30 minutes[(a)]	N/A	
Temperature of thrust chamber throat at engine start	-300° to -150° F	-300° to -150° F	-300° to -80° F	N/A	

(a) If thrust chamber conditioning is prematurely terminated before booster ignition, activate thrust chamber jacket ambient helium purge (see figure 2-4). The thrust chamber conditioning purge must be reactivated at least 7-1/2 minutes before booster ignition. Maximum duration of purge varies for each stage application and is based on stage limitations, not engine requirements.

Figure 3-58. Engine Conditioning Before Launch (Sheet 1 of 4)

Procedure	SIB Vehicle	SV Vehicle			Remarks
	SIVB Stage	SII Stage	SIVB-Stage First Start	SIVB-Stage Second Start	
FUEL SYSTEM CONDITIONING					The engine fuel-system fuel suction line, fuel pump, main high-pressure fuel duct to MFV, and GG fuel line to fuel bleed line connection will be conditioned.
Propellant in engine system before start	1/2 hour minimum	1/2 hour minimum	1/2 hour minimum	3 minutes minimum	
Duration of fuel circulation:					
Total	5 minutes minimum	5 minutes minimum	5 minutes minimum	3 minutes minimum	
With subcooled liquid at engine inlet before engine start	3 minutes minimum	3 minutes minimum	3 minutes minimum	3 minutes minimum	
Circulation flowrate	0.9 to 2.0 lb/sec	0.9 to 2.0 lb/sec	0.9 to 2.0 lb/sec	0.9 to 2.0 lb/sec	Refer to R-3825-1 for information on bleed flow during engine conditioning.
Engine inlet propellant condition at engine start	See figures 2-7 and 2-9.	See figures 2-7 and 2-9.	See figures 2-7 and 2-9.	See figures 2-7 and 2-9.	

Figure 3-58. Engine Conditioning Before Launch (Sheet 2 of 4)

Procedure	SIB Vehicle	SV Vehicle			Remarks
	SIVB Stage	SII Stage	SIVB-Stage First Start	SIVB-Stage Second Start	
<u>FUEL SYSTEM CONDITIONING</u>					The engine fuel-system fuel suction line, fuel pump, main high-pressure fuel duct to MFV, and GG fuel line to fuel bleed line connection will be conditioned.
Propellant in engine system before start	1/2 hour minimum	1/2 hour minimum	1/2 hour minimum	3 minutes minimum	
Duration of fuel circulation:					
Total	5 minutes minimum	5 minutes minimum	5 minutes minimum	3 minutes minimum	
With subcooled liquid at engine inlet before engine start	3 minutes minimum	3 minutes minimum	3 minutes minimum	3 minutes minimum	
Circulation flowrate	0.9 to 2.0 lb/sec	0.9 to 2.0 lb/sec	0.9 to 2.0 lb/sec	0.9 to 2.0 lb/sec	Refer to R-3825-1 for information on bleed flow during engine conditioning.
Engine inlet propellant condition at engine start	See figures 2-7 and 2-9.	See figures 2-7 and 2-9.	See figures 2-7 and 2-9.	See figures 2-7 and 2-9.	

Figure 3-58. Engine Conditioning Before Launch (Sheet 2 of 4)

Procedure	SIB Vehicle	SV Vehicle			Remarks
	SIVB Stage	SII Stage	SIVB-Stage First Start	SIVB-Stage Second Start	
<u>OXIDIZER SYSTEM CONDITIONING</u>					The engine oxidizer system oxidizer suction line, oxidizer pump, main high-pressure oxidizer duct to MOV, and GG oxidizer line to oxidizer bleed line connection will be conditioned.
Propellants in engine system before start	1 hour minimum	2 hours minimum	1 hour minimum	3 minutes minimum	
Duration of oxidizer circulation:					
Total	Oxidizer circulation flowrate and duration must be sufficient to obtain temperature of 3° F subcooled or colder (figure 2-8) in oxidizer high-pressure duct before engine start (measured at instrumentation port POT3).				
With subcooled liquid at engine inlet before engine start	3 minutes minimum	3 minutes minimum	3 minutes minimum	3 minutes minimum	
Circulation flowrate	Oxidizer circulation flowrate must be sufficient to obtain temperature of 3° F subcooled or colder (figure 2-8) in oxidizer high-pressure duct before engine start (measured at instrumentation port POT3).				Refer to R-3825-1 for information on bleed flow during engine conditioning.
Engine inlet propellant condition at engine start	See figures 2-5 and 2-7.	See figures 2-5 and 2-7.	See figures 2-5 and 2-7.	See figures 2-5 and 2-7.	

Figure 3-58. Engine Conditioning Before Launch (Sheet 3 of 4)

Procedure	SIB Vehicle	SV Vehicle			Remarks
	SIVB Stage	SII Stage	SIVB-Stage First Start	SIVB-Stage Second Start	
<u>START TANK CONDITIONING</u>					
Condition at engine start:					
Hydrogen pressure and temperature	See figure 2-11.	See figure 2-11.	See figure 2-11.	Values established by conditions within engine system after completed firing duration of 150 seconds followed by a 1-1/2 to 6-hour coast in earth orbit.	
<u>HELIUM TANK CONDITIONING</u>					
Condition at engine start:					
Helium pressure	2,800-3,450 psia	2,800-3,450 psia	2,800-3,450 psia	Values established by conditions within engine system after completed firing duration of 150 seconds followed by a 1-1/2 to 6-hour coast in earth orbit.	
Helium temperature	Helium temperature must be within same temperature range as selected hydrogen start-tank conditioning.	Helium temperature must be within same temperature range as selected hydrogen start-tank conditioning.	Helium temperature must be within same temperature range as selected hydrogen start-tank conditioning.		

Figure 3-58. Engine Conditioning Before Launch (Sheet 4 of 4)

NOTE

The start tank vent-and-relief valve may start to relieve at a low flow-rate at 1,250 psia. The pressure at which relief occurs may differ from valve to valve but the valve must be capable of maintaining the start tank pressure between 1,250 and 1,400 psia under conditions that permit normal warmup of the start tank gas. Relief valve performance may vary due to normal variations in relief valve operating characteristics and the heat input.

e. After pressurizing engine helium and start tanks to specified limits, make sure helium tank and start tank fill check valves have seated by monitoring tank instrumentation. Tank pressures must remain with requirements of figure 3-57 or 3-58.

CAUTION

If the engine start tank vent-and-relief valve does not function, as indicated by no reduction in start tank pressure, proceed immediately to emergency procedures of paragraph 3.5.5. Overpressurization of the start tank can result in damage to the engine or stage.

f. If start tank pressure exceeds a maximum value of 1,400 psia, immediately vent start tank to a safe pressure level (below 1,400 psia) by opening engine start tank vent-and-relief valve.

3.5.5 ENGINE START TANK EMERGENCY DEPRESSURIZATION. This procedure is to be used only when the capability for venting the start tank by use of the start tank vent-and-relief valve fails.

a. Maintain continuous monitoring of all stage/engine instrumentation.

b. Immediately terminate start tank fill (all engines on SII stage).

c. Energize start tank emergency vent valve. When start tank pressure has decreased to zero, deenergize start tank emergency vent valve.

d. On SII stage, vent all unaffected engine start tanks using start tank vent-and-relief valves.

3.5.6 CONDITIONING ENGINE FOR STATIC TEST. To provide a successful engine start, condition engine as outlined in figure 3-57.

3.5.7 CONDITIONING ENGINE BEFORE LAUNCH. To provide a successful engine start, condition engine as outlined in figure 3-58.

3.5.8 DRYING UNINSTALLED ENGINE. The drying procedures can be used to dry each system or the complete engine system, as required. When drying the complete engine system, the drying sequence requirements of section I must be observed. If test equipment is being used in subsequent drying procedures, it is not necessary to secure the test equipment. The start tank vent valve control cavity, mainstage OK pressure checkout line, and propellant and oxidizer turbine bypass valve linkage housings are isolated systems; drying may be accomplished at any time during the complete engine system drying sequence. During the drying procedure, all actuations and deactuations of the helium regulator assembly and the pressure levels of each operation must be recorded in the Engine Log Book, Helium Regulator Assembly Operation Record. Connections disturbed during engine drying procedures must be leak tested during subsequent engine leak and function testing. Test equipment is listed in figure 3-59.

Part Number	Nomenclature	Use
G1037	Electrical Checkout Console	Supplies electrical power to engine components.
G3106	Pneumatic Checkout Console	Supplies regulated pneumatic pressure to engine components.
9016713	Turbopump Inlet Ducts Test Plate Kit	Seals oxidizer and fuel inlet ducts and provides connections for pneumatic purge and pressure monitor.
9016724	Customer Connection Test Plate Kit, 5/8-inch	Seals start tank vent valve control customer connect and provides connection for actuating valve during system drying.
9017373	Customer Connection Test Plate Kit, 5/8-inch	Seals start tank customer connect and provides purge port for system drying.
9017274	Customer Connection Test Plate Kit, 5/8-inch	Seals helium tank fill customer connect and provides pressurization port for system drying.
9018840	Customer Connection Test Plate Kit, 1/2-inch	Seals oxidizer bleed line customer connect and provides connection for purge during drying GG propellant lines.
9018843-11	Customer Connection Test Plate Kit, 5/8-inch	Seals purge manifold and thrust chamber jacket purge customer connections and provides purge port for system drying.
9020266	Customer Connection Test Oxidizer Tank Pressurization Plate Kit	Seals hydrogen tank pressurization customer connect and provides purge port during gaseous refill check valve drying.
9025400-11	P/A Purge Valve Test Plate Kit	Seals and provides connection on STDV outlet flange during start system drying.
9025419	Fuel Pump Leak and Flow Adapter Kit	Used to purge and monitor gages during fuel pump drain customer-connect drying.
9022750-11	Start Tank Discharge Valve Adapter Set	Seals outlet flange of STDV during start system drying.
9024512-91 (A51) and 9024512-101 (A54)	Cable Adapter	Connects Electrical Checkout Console G1037 to engine cables.

Figure 3-59. Test Equipment for Drying Uninstalled Engine (Sheet 1 of 2)

Part Number	Nomenclature	Use
NA5-27093TP208 and NA5-27093TP281	Electrical Cable	Connects Electrical Checkout Console G1037 to engine cables.
NA5-27093TP212	Electrical Cable	Consists of a facility jumper cable for Electrical Checkout Console G1037.
NA5-27093TP213	Electrical Cable	Provides power for Pneumatic Checkout Console G3106.
--	Humidity and temperature measuring equipment with a 3-42 percent relative humidity range of 80° F, and a -20° to +140° F temperature range (Hydrodynamics, Inc, or equivalent).	Measures relative humidity and temperature of exhaust gases during engine drying.
--	Vacuum pump capable of obtaining vacuum requirements of figure 1-12 (No. 54960, Van Waters and Rogers, Inc).	Evacuates moisture-laden gases from component.
--	Gage or monometer (must be accurate to ±1 millimeter at required vacuum condition).	
9019969	Start tank liquid refill line test plate	Seals and provides connection on liquid refill line during drying of start system and on GG valve opening control port during drying of GG control valve and GG propellant lines.
9019968	Start tank gaseous refill line test plate	Seals and provides connection on gaseous refill line and heat exchanger oxidizer supply line during drying.
9025826	Vacuum Manifold	Interconnects start system components and drying equipment during start system drying.
EWR129666	Spacer	Placed between STDV swing gate check valve [illegible]d se[illegible] [illegible]e sure STDV body cavity is [illegible]osed to vacuum during drying.
--	Shutoff Valves (3 required)	To control vacuum draw and gas flow from drying equipment and vacuum manifold.

Figure 3-59. Test Equipment for Drying Uninstalled Engine (Sheet 2 of 2)

3.5.8.1 Preparing Pneumatic and Electrical Consoles. Helium and nitrogen used for drying must conform to the requirements in section II. Gaseous nitrogen (preferred for drying) or gaseous helium can be used for drying the engine. If gaseous nitrogen is used in the pneumatic system, the pneumatic system must be purged using the pneumatic system drying procedure.

a. Supply the following regulated electrical and pneumatic sources to ground support equipment:

(1) 24-30 vdc, 15 amperes, to Electrical Checkout Console G1037.

(2) Gaseous nitrogen or gaseous helium (refer to section II) capable of supplying a minimum of 1,000-psig regulated pressure to Pneumatic Checkout Console G3106. Air conforming to the requirements of MSFC-PROC-404 is an acceptable alternate-drying agent for gaseous nitrogen.

b. Prepare and connect electrical checkout console and pneumatic checkout console to engine as follows:

(1) Make sure all consoles, engine, and engine handler are grounded to a common ground.

CAUTION

Engine power must not be turned on when the spark igniter cables are disconnected, since damage to equipment can result.

(2) Make sure all switches and circuit breakers are in off, neutral, or deenergized position.

(3) Make sure that all pneumatic regulators are in off or closed position.

(4) Remove covers and closures, as necessary, and make electrical and pneumatic connections as shown in figure 3-60.

c. When preparing electrical consoles for drying fuel system, oxidizer system, start system, turbine and exhaust system, engine pneumatic system, or complete engine system, position switches on electrical checkout console as follows: (COMPONENT TEST light on ENGINE TEST/MONITOR panel comes on. Disregard all other lights.)

(1) PRE-VALVES on SIMULATOR panel to CLOSED.

(2) FACILITY READY on SIMULATOR panel to FACILITY READY.

(3) TEST/FIRE SELECT on GROUND RELAY panel to OK TO TEST.

(4) Test selector on ENGINE TEST/MONITOR panel to COMPONENT TEST.

(5) ENGINE GROUND POWER on ENGINE CONTROL panel to ON.

3.5.8.2 Drying Thrust Chamber Jacket.

a. Prepare pneumatic checkout console (paragraph 3.5.8.1).

NOTE

Pneumatic supply to engine pneumatic system is not required for drying thrust chamber jacket.

b. Remove the following engine closures:

(1) Thrust chamber exit closure. (Allow closure to partially cover exit.)

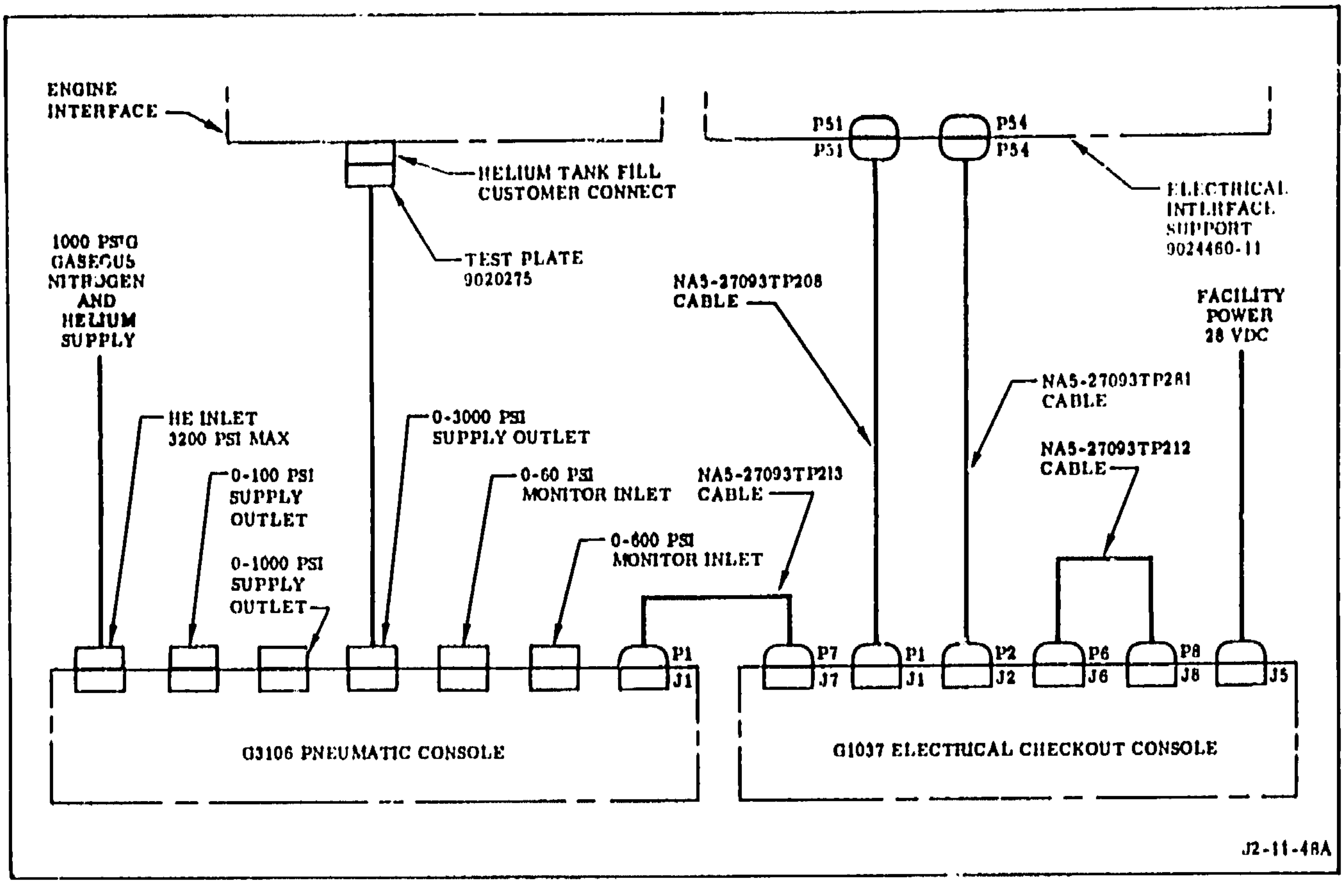


Figure 3-60. Electrical and Pneumatic Connections for Drying Uninstalled Engine

(2) HYDROGEN TANK PRESSURIZATION customer connect.

c. Install test plate 9020222-11 from plate kit 9018843-11 on THRUST CHAMBER JACKET PURGE.

d. Use a tee fitting and connect pressure hoses from 0-1,000 PSI SUPPLY OUTLET and 0-600 PSI MONITOR INLET on pneumatic checkout console to test plate 9020222-11.

e. Using humidity and temperature measuring equipment (figure 3-59), place sensor in thrust chamber at injector. Do not allow sensor to touch injector or thrust chamber walls. Place indicator as close as possible to thrust chamber exit, to permit switching from humidity to temperature measurement.

f. Turn on facility supply (1,000 psig minimum) to pneumatic checkout console.

g. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to maintain a maximum of 85 psig on PNEUMATIC MONITOR PANEL (0-600).

h. Continue purge until indicated humidity is within limits of figure 1-13.

i. Decrease pressure to zero on PNEUMATIC SUPPLY PANEL (0-1,000).

j. Remove hoses and test plate from THRUST CHAMBER JACKET PURGE customer connect. Remove humidity and temperature measuring equipment.

k. Install protective closures on HYDROGEN TANK PRESSURIZATION THRUST CHAMBER JACKET PURGE customer connects and thrust chamber exit.

l. Secure pneumatic checkout console if no further drying is to be performed (paragraph 3.5.8.17).

3.5.8.3 Drying Fuel System. The turbopump inlet duct support must be installed during drying of the fuel system. Helium regulator actuations performed during fuel system drying must be recorded.

a. Prepare pneumatic and electrical consoles (paragraph 3.5.8.1).

b. Remove the following engine closures:

(1) Thrust chamber exit closure. (Allow closure to partially cover exit.)

(2) Oxidizer turbine seal drain.

(3) Oxidizer pump seal drain at thrust chamber exit.

(4) Intermediate seal purge.

NOTE

The test plate inlet port is orificed, requiring purging through the test plate monitor port.

c. Remove fuel inlet duct closure, and install test plate 9019858 from test kit 9016713 on fuel pump inlet duct. Install pressure cap on inlet port.

d. Use a tee fitting and connect pressure hoses from 0-1,000 PSI SUPPLY OUTLET and 0-60 PSI MONITOR INLET to monitor port on test plate 9019858.

e. Remove closure, and tape a plastic bag over FUEL BLEED LINE customer connect. Cut a hole in plastic bag, and insert humidity and temperature sensor. (See figure 3-59.) Do not allow sensor to touch flanges or walls of bleed line. Vent plastic bag to atmosphere.

f. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to 30 ±5 psi on PNEUMATIC MONITOR PANEL (0-60) gage.

g. Continue purge until humidity is within limits of figure 1-13.

h. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to zero.

i. Remove humidity and temperature sensor and plastic bag from FUEL BLEED LINE customer connect. Install protective closure.

j. Install humidity and temperature measuring equipment. Place sensor in thrust chamber at injector. Do not allow sensor to touch injector or thrust chamber walls. Place indicator as close as possible to thrust chamber exit to permit switching from humidity to temperature measurement.

Operation	Result
k. Position the following switches on electrical checkout console to ON:	
(1) HELIUM CONTROL on ENGINE TEST/MONITOR panel).	HELIUM CONTROL light comes on.
(2) IGNITION PHASE CONTROL ENGINE TEST/MONITOR panel.	IGNITION PHASE CONTROL light comes on.

Operation	Result
(3) MAINSTAGE CONTROL on ENGINE TEST/MONITOR panel.	MAINSTAGE CONTROL light comes on.

l. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-3,000) to 225-250 psig.

m. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to 30 ±5 psi as indicated on PNEUMATIC MONITOR PANEL (0-60).

n. Continue purge until humidity is within limits of figure 1-13.

o. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to zero.

p. Position the following switches on the electrical checkout console to OFF.	
(1) MAINSTAGE CONTROL on ENGINE TEST/MONITOR panel.	MAINSTAGE CONTROL light goes off.
(2) IGNITION PHASE CONTROL on ENGINE TEST/MONITOR panel.	IGNITION PHASE CONTROL light goes off.

q. Reduce pressure on PNEUMATIC SUPPLY PANEL (0-3,000) to zero. Allow pneumatic system to vent.

r. When pressure in pneumatic system has vented, position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	HELIUM CONTROL light goes off.

s. If nitrogen was used in pneumatic system, dry pneumatic system unless complete engine drying is being performed. (Refer to paragraph 3. 5. 8. 13.)

t. Disconnect pressure hoses from test plate 9019858, remove test plate from fuel pump inlet duct, and remove humidity indicator from thrust chamber.

u. If no further drying is to be performed, install desiccant and closure on fuel pump inlet duct.

v. Install protective closures removed in step b.

w. Secure pneumatic and electrical consoles if no further drying is to be performed (paragraph 3. 5. 8. 17).

3. 5. 8. 4 Drying Fuel Pump Drain Customer Connect.

a. Prepare pneumatic checkout console (paragraph 3. 5. 8. 1).

NOTE

Pneumatic supply to the engine pneumatic system is not required for drying the fuel pump drain customer connect.

b. Remove closure from fuel turbine seal drain line.

c. Remove plug from fitting in fuel pump drain line, and install adapter 9025420 from adapter kit 9025419.

d. Use a tee fitting and connect pressure hoses from 0-100 PSI SUPPLY OUTLET and 0-600 PSI MONITOR INLET on pneumatic checkout console to adapter 9025420.

e. Remove fuel inlet duct closure, and install test plate 9019858 from plate kit 9016713 on fuel pump inlet duct. Make sure pressure cap is installed on inlet port.

f. Connect a pressure hose from 0-60 PSI MONITOR INLET on pneumatic checkout console to test plate 9019858 on fuel pump inlet duct.

g. Remove closure, and tape a plastic bag over FUEL PUMP DRAIN customer connect. Cut a hole in plastic bag, and insert humidity and temperature sensor (figure 3-59). Do not allow sensor to touch flanges or walls of drain line. Vent plastic bag to atmosphere.

CAUTION

Exceeding 30 psig in the fuel pump can result in damage to the engine.

h. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-100) to maintain 40-60 psig on PNEUMATIC MONITOR PANEL (0-60). Do not exceed 30 psig on PNEUMATIC MONITOR PANEL (0-60). Maintain 30 psig by venting excess pressure using BLEED valve on PNEUMATIC MONITOR PANEL (0-60).

i. Continue purge until indicated humidity is within limits of figure 1-13.

j. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-100) to zero.

k. Remove hoses and adapter from fuel pump drain line. Install plug and torque plug to 65-70 in-lb. Refer to R-3825-3 for handling and installing seal (Naflex).

l. Remove test plate from fuel inlet duct, and remove bag and humidity and temperature sensor from FUEL PUMP DRAIN customer connect.

m. Install protective closures on fuel inlet duct, fuel turbine seal drain line, and FUEL PUMP DRAIN customer connect.

n. Secure pneumatic checkout console if no further drying is to be performed (paragraph 3.5.8.17).

3.5.8.5 Drying Oxidizer Feed System. The turbopump inlet duct support must be installed during drying of the oxidizer feed system. Helium regulator actuations performed during drying of the oxidizer feed system must be recorded.

a. Prepare pneumatic and electrical consoles (paragraph 3.5.8.1).

b. Remove the following engine closures:

(1) Thrust chamber exit closure. (Allow closure to partially cover exit.)

(2) Oxidizer turbine seal drain.

(3) Oxidizer pump seal drain at thrust chamber exit.

(4) Intermediate seal purge.

NOTE

The test plate inlet port is orificed, requiring purging through the test plate monitor port.

c. Remove oxidizer inlet duct closure, install test plate 9019858 from kit 9016713 on oxidizer pump inlet duct. Make sure pressure cap is installed on inlet port of test plate.

d. Use a tee fitting and connect pressure hoses from 0-1,000 PSI SUPPLY OUTLET and 0-60 PSI MONITOR INLET to monitor port on test plate 9019858.

e. Remove closure, and tape a plastic bag over LOX BLEED LINE customer connect. Cut a hole in plastic bag and insert humidity and temperature sensor (figure 3-59). Do not allow sensor to touch flanges or walls of bleed line. Vent plastic bag to atmosphere.

f. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to 30 ±5 psi as indicated on PNEUMATIC MONITOR PANEL (0-60).

g. Continue purge until indicated humidity is within limits of figure 1-13.

h. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to zero, and remove plastic bag and humidity indicator from LOX BLEED LINE customer connect.

i. Install protective closure on LOX BLEED LINE customer connect.

j. Install humidity and temperature measuring equipment in thrust chamber. Place sensor in thrust chamber at injector. Do not allow sensor to touch injector or thrust chamber walls. Place indicator as close as possible to thrust chamber exit to permit switching from humidity to temperature measurement.

Operation	Result
k. Position the following switches on electrical checkout console to ON:	
(1) HELIUM CONTROL on ENGINE TEST/MONITOR panel.	HELIUM CONTROL light comes on.
(2) IGNITION PHASE CONTROL ENGINE TEST/MONITOR panel.	IGNITION PHASE CONTROL light comes on.
(3) MAINSTAGE CONTROL on ENGINE TEST/MONITOR panel.	MAINSTAGE CONTROL light comes on.

l. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-3,000) to 225-250 psig.

m. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to 30 ±5 psi as indicated on PNEUMATIC MONITOR PANEL (0-60).

n. Continue purge until indicated humidity is within limits of figure 1-13.

o. Decrease pressure on 0-1,000 PNEUMATIC SUPPLY PANEL to zero.

Operation	Result
p. Position MAINSTAGE CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	MAINSTAGE CONTROL light goes off.

q. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to 30 ±5 psig as indicated on PNEUMATIC MONITOR PANEL (0-60). Continue purge until indicated humidity is within limits of figure 1-13.

r. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to zero.

Operation	Result
s. Position IGNITION PHASE CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	IGNITION PHASE CONTROL light goes off.

t. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-3,000) to zero. Allow pressure in pneumatic system to vent.

Operation	Result
u. When pressure in pneumatic system has vented, position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	HELIUM CONTROL light goes off.

v. If nitrogen was used in pneumatic system, dry pneumatic system unless complete engine drying is being performed. (Refer to paragraph 3.5.8.13.)

w. Remove hose and test plate from oxidizer pump inlet duct. Remove humidity and temperature measuring equipment from thrust chamber.

x. If no further drying is to be performed, install protective closure and desiccant on oxidizer pump inlet duct.

y. Install protective closures removed in step b.

z. Secure pneumatic and electrical consoles if no further drying is to be performed (paragraph 3.5.8.17).

3.5.8.6 Drying Oxidizer Pump Primary Seal Drain Customer Connect (Engines Incorporating MD301, MD302, MD322, or MD323 Change).

a. Prepare pneumatic checkout console (paragraph 3.5.8.1).

NOTE

Pneumatic supply to the engine pneumatic system is not required for drying the oxidizer turbopump primary seal drain customer connect.

b. Install test plate 9020222-11 from kit 9018843-11 on engine OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.

c. Connect a pressure hose from 0-100 PSI SUPPLY OUTLET on pneumatic checkout console to test plate 9020222-11.

d. Remove closure, and tape a plastic bag over oxidizer pump seal drain line at thrust chamber exit. Cut a hole in plastic bag, and insert humidity and temperature sensor. Do not allow sensor to touch flanges or walls of drain line. Vent plastic bag to atmosphere.

e. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-100) to 30 ±5 psig.

f. Continue purge until indicated humidity is within limits of figure 1-13.

g. Decrease pressure to zero on 0-100 PNEUMATIC SUPPLY PANEL.

h. Remove test plate from OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect, and remove bag and humidity and temperature sensor from oxidizer pump seal drain line.

i. Install protective closures on oxidizer pump seal drain line and OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.

j. Secure pneumatic checkout console if no further drying is to be performed. (Refer to paragraph 3.5.8.17.)

3.5.8.7 Drying Start System. When performing this procedure, the following purge sequence must be observed: (1) start tank liquid refill line, (2) start tank gaseous refill line, and (3) start tank initial fill line.

a. Prepare pneumatic checkout console (paragraph 3.5.8.1).

NOTE

Pneumatic supply to the engine pneumatic system is not required to dry the start system.

b. Install test plate 9020274 from plate kit 9017273 on START TANK INITIAL FILL customer connect. Torque bolts to 61-75 in-lb.

c. Install test plate 9020223 from plate kit 9016724 on START TANK VENT VALVE CONTROL customer connect, and torque bolts to 61-75 in-lb. Connect a pressure hose from 0-1,000 PSI SUPPLY OUTLET to test plate.

d. Disconnect start tank liquid refill line at flange connection to ASI lower fuel line. Remove and retain seal.

CAUTION

Installation of test plate without seal can damage protruding orifice in start tank refill line.

e. Install test plate 9025853 from kit 9019969 on start tank liquid refill line. Torque nuts to 61-75 in-lb.

f. Disconnect start tank gaseous refill line at thrust chamber injector fuel manifold. Observe position of bracket 502829 for reinstallation. Remove and retain seal.

g. Install test plate 9025871 from kit 9010968 on start tank gaseous refill line. Torque nuts to 61-75 in-lb.

h. Remove bolts and washers that secure STDV discharge hose to STDV. Disconnect hose and remove seal. Secure hose, as necessary, to support hose and to obtain clearance to install test plate.

i. Install protective cover on open flange of STDV discharge hose.

j. Install spacer EWR129666 between STDV swing gate and gate sealing surface. Be extremely careful to prevent damage to sealing surfaces.

k. Obtain test plate 9022752 and the following from STDV adapter set 9022750-11:

(1) Seal RD261-3010-0070.

(2) Eight bolts NAS1006-29A.

(3) Eight washers RD153-5004-0006.

l. Install test plate 9022752 on outlet flange of STDV with bolts and washers from STDV adapter set 9022750-11. Torque bolts to 252-308 in-lb.

m. Remove bolts and washers that secure drain line to STDV (port E). Install test plate 9025399 from test plate kit 9025400-11 between drain line flange and valve drain port. Be careful to prevent distortion of line. Torque bolts to 41-45 in-lb.

NOTE

Steps n through aa purge dry the start system.

n. Connect a pressure hose from 0-100 PSI SUPPLY OUTLET to test plate installed on start tank liquid refill line.

o. Remove closure, and tape a plastic bag over START TANK VENT & RELIEF VALVE DRAIN customer connect. Cut a hole in plastic bag, and insert humidity and temperature sensor. Do not allow sensor to touch flanges or walls of customer connect line. Vent plastic bag to atmosphere.

Operation	Result
p. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to 250 ±25 psig.	Start-tank vent valves opens.

q. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-100) to 50 ±5 psig.

r. Continue purge until indicated humidity is within limits of figure 1-13.

s. Decrease flow on PNEUMATIC SUPPLY PANEL (0-100) to zero. When all flow has vented, decrease pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to zero.

t. Disconnect pressure hose from test plate installed on start tank liquid refill line and install pressure cap on test plate.

u. Connect pressure hose from 0-100 PSI SUPPLY OUTLET to test plate installed on start tank gaseous refill line.

v. Repeat steps p through s.

w. Disconnect pressure hose from test plate installed on start tank gaseous refill line, and install pressure cap on test plate.

x. Connect pressure hose from 0-100 PSI SUPPLY OUTLET to test plate 9020274 on START TANK INITIAL FILL customer connect.

y. Repeat steps p through s.

z. Disconnect pressure hose from test plate 9020274 on START TANK INITIAL FILL customer connect, and install pressure cap on test plate.

aq. Close shutoff valve in vacuum monitor gage line (if installed), open shutoff valve between pressure hose and vacuum manifold, and adjust pressure on PNEUMATIC SUPPLY PANEL (0-100) to 2 psig maximum to backfill start system with helium.

ar. Close shutoff valve between pressure hose and vacuum manifold; then decrease pressure on PNEUMATIC SUPPLY PANEL (0-100) to zero and vent.

as. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to zero.

NOTE

During subsequent operations, all openings in the start system must remain capped except when making required connections. Once reassembly of the start system is begun, it must be completed as soon as possible to minimize contamination by moisture.

at. Disconnect vacuum lines from testplates. Install protective cap on test plate immediately after disconnecting line from each test plate.

au. Disassemble and remove vacuum hardware.

av. Remove test plate from start tank gaseous refill line. Using new seal, connect refill line to thrust chamber injector fuel manifold flange. Using bolts RD111-1009-3428, install bracket 502829 in same location as before removal. Torque bolts to 43-47 in-lb, and safetywire, as required.

aw. Remove test plate from start tank liquid refill line. Using new seal, connect refill line to ASI lower fuel line. Torque bolts to 52-58 in-lb, and safetywire.

CAUTION

During removal of spacer, extreme care must be taken to prevent damage to sealing surfaces.

ax. Remove test plate 9022752 from STDV outlet, and carefully remove spacer from between STDV swing gate and gate sealing surfaces.

ay. Remove protective closure from STDV discharge hose, install new seal, and connect hose to STDV with bolts and washers. Torque bolts to 314-316 in-lb, and safetywire.

az. Remove bolts and washers that secure STDV drain line to STDV, and remove test plate. Install new seal, and connect drain line to STDV with bolts and washers. Torque bolts to 42-45 in-lb, and safetywire.

ba. Remove pressure hose and test plate from START TANK INITIAL FILL customer connect, and install protective closure.

bb. Remove pressure hose and test plate from START TANK VENT VALVE CONTROL, and install protective closure.

bc. Remove test plate from START TANK VENT & RELIEF VALVE DRAIN customer connect, and install protective closure.

bd. Remove plugs and packings from test plates.

be. Install new packings MS28778-6 lubricated with sealing and antiseize compound RB0140-005 (Rocketdyne) on burst diaphragms.

bf. Reinstall burst diaphragm on test plates. Torque to 100-150 in-lb, and safetywire.

bg. Secure pneumatic and electrical consoles if no further drying is to be performed (paragraph 3.5.8.17).

3.5.8.8 Drying Turbine and Exhaust System. All helium regulator actuations performed during drying of the start tank and exhaust system must be recorded.

a. Prepare pneumatic and electrical consoles (paragraph 3.5.8.1).

b. Remove the following engine closures:

(1) Thrust chamber exit closure. (Allow closure to partially cover exit.)

(2) Oxidizer turbine seal drain.

(3) Oxidizer pump seal drain at thrust chamber exit.

(4) Fuel turbine seal drain.

(5) Intermediate seal purge.

c. Install test plate 9020274 from plate kit 9017273 on START TANK INITIAL FILL customer connect, and connect a pressure hose from 0-1,000 PSI SUPPLY OUTLET to test plate.

d. Install test plate 9020223 from plate kit 9016724 on START TANK VENT VALVE CONTROL customer connect.

e. Remove closure from over START TANK VENT & RELIEF VALVE DRAIN customer connect.

f. Install humidity and temperature sensor in thrust chamber at exhaust ports by suspending sensor in a box or container. Position container to cover several exhaust ports. Do not allow sensor to touch thrust chamber or exhaust ports. Place indicator as close as possible to thrust chamber exit to permit switching from humidity to temperature measurements.

Operation	Result
g. Position the following switches on electrical checkout console to ON:	
(1) HELIUM CONTROL on ENGINE TEST/MONITOR panel.	HELIUM CONTROL light comes on.
(2) MAINSTAGE CONTROL on ENGINE TEST/MONITOR panel.	MAINSTAGE CONTROL light comes on.

WARNING

Failure to observe safety requirements of step h can result in injury or death to personnel.

h. Clear personnel from immediate area of engine, or make sure personnel stand behind adequate safety barriers. Adjust pressure on 0-3,000 PNEUMATIC SUPPLY panel to 375-425 psig.

Operation	Result
i. Position MAINSTAGE CONTROL on ENGINE TEST/MONITOR panel to OFF.	MAINSTAGE CONTROL light goes off.

j. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-3,000) to 225-250 psig. Personnel may enter area.

k. Position the following switches to ON:	
(1) IGNITION PHASE CONTROL on ENGINE TEST/MONITOR panel.	IGNITION PHASE CONTROL light comes on.
(2) START TANK DISCHARGE CONTROL ENGINE TEST/MONITOR panel.	START TANK DISCHARGE CONTROL light comes on.

CAUTION

After start tank has been pressurized, STDV must not be closed until pressure has been reduced to zero. If the STDV should be accidentally closed, the start tank must be vented as outlined in steps t, u, and v before reopening the valve, since damage to equipment can result.

l. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-1,000) until purge flow is detected at thrust chamber exhaust ports. Do not exceed 500 psi on REG SUPPLY PRESSURE gage.

m. Continue purge until indicated humidity is within limits of figure 1-13.

Operation	Result
n. Position MAINSTAGE CONTROL switch on ENGINE TEST/MONITOR panel to ON. Continue purge until indicated humidity is within limits of figure 1-13.	MAINSTAGE CONTROL light goes on.

o. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to zero.

p. Position the following switches on the electrical checkout console to OFF:	
(1) START TANK DISCHARGE CONTROL on ENGINE TEST/MONITOR panel.	START TANK DISCHARGE CONTROL light goes off.
(2) IGNITION PHASE CONTROL on ENGINE TEST/MONITOR panel.	IGNITION PHASE CONTROL light goes off.
(3) MAINSTAGE CONTROL on ENGINE TEST/MONITOR panel.	MAINSTAGE CONTROL light goes off.

q. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-3,000) to zero. Allow pressure in pneumatic system to vent.

r. When pressure in pneumatic system has vented, position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	HELIUM CONTROL light goes off.

s. Remove pressure hose and test plate from START TANK INITIAL FILL customer connect, and install protective closure.

t. Remove pressure cap, and connect pressure hose from 0-1,000 PSI SUPPLY OUTLET on pneumatic console to test plate 9020223 on START TANK VENT VALVE CONTROL customer connect.

u. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to 250 ±25 psig.

v. When all start tank pressure has vented, decrease pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to zero.

w. Remove pressure hose and test plate from START TANK VENT VALVE CONTROL and install protective closures on START TANK VENT VALVE CONTROL and START TANK VENT & RELIEF VALVE DRAIN customer connect.

x. If nitrogen was used in pneumatic system, dry pneumatic system unless complete engine drying is being performed. (Refer to paragraph 3.5.8.13.)

y. Remove humidity and temperature measuring equipment from thrust chamber.

z. Install protective closures removed in step b.

aa. Secure pneumatic and electrical consoles if no further drying is to be performed. (Refer to paragraph 3.5.8.17.)

3.5.8.9 Drying Gas Generator and Propellant Lines.

a. Prepare pneumatic checkout console (paragraph 3.5.8.1).

NOTE

Pneumatic supply to the engine pneumatic system is not required for drying the GG control valve and GG propellant lines.

b. Install test plate 9020526 from plate kit 9018840 on LOX BLEED LINE customer connect.

c. Use a tee fitting and connect pressure hoses from 0-100 PSI SUPPLY OUTLET and 0-60 PSI MONITOR INLET on pneumatic console to test plate 9020526.

d. Remove oxidizer inlet duct closure; install test plate 9019858 from kit 9016713 on oxidizer pump inlet duct. Make sure pressure caps are installed on ports of test plate.

e. Disconnect mainstage control manifold from GG control valve. Note position of bracket for reinstallation. Remove seal and retain.

NOTE

It may be necessary to disconnect mainstage control manifold (inlet line) from fast-shutdown valve to obtain clearance to install test plate on GG control valve.

f. Install test plate 9025853 from kit 9019969 on GG control valve opening control port. Torque bolts to 41-45 in-lb.

g. Install protective closure on mainstage control manifold.

h. Connect pressure hose from 0-1,000 PSI SUPPLY OUTLET to test plate on GG control valve opening control port.

i. Partially remove thrust chamber exit closure to allow flow of purge gases.

j. Install humidity and temperature sensor in thrust chamber at exhaust ports by suspending sensor in a box or container. Position container to cover several exhaust ports. Do not allow sensor to touch thrust chamber or exhaust ports. Place indicator as close as possible to thrust chamber exit to permit switching from humidity to temperature measurements.

k. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to 225-250 psig.

l. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-100) to 30 ±5 psi as indicated on PNEUMATIC MONITOR PANEL (0-60).

m. Continue purge until indicated humidity is within limits of figure 1-13.

n. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-100) to zero.

o. Remove pressure hose and test plate 9020526 from LOX BLEED LINE customer connect. Install protective closure.

p. Remove test plate 9019858 from oxidizer pump inlet duct, and install test plate on fuel pump inlet duct. Install protective closure on oxidizer pump inlet duct.

q. Install test plate 9020526 (removed in step o) on FUEL BLEED LINE customer connect.

r. Connect pressure hoses from 0-100 PSI SUPPLY OUTLET and 0-30 PSI MONITOR INLET on pneumatic checkout console to test plate 9020526.

s. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-100) to maintain 30 ±5 psig on PNEUMATIC MONITOR PANEL (0-60).

t. Continue purge until indicated humidity is within limits of figure 1-13.

u. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-100) to zero.

v. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to zero.

w. Remove pressure hoses test plate from FUEL BLEED LINE customer connect and fuel pump inlet duct. Install protective closures.

x. Remove humidity and temperature measuring equipment from thrust chamber. Install thrust chamber exit closure.

y. Remove pressure hose and test plate from GG control valve.

z. Install new seal, mainstage control manifold, and bracket on GG control port with bolts and washers. Torque bolts to 41-45 in-lb, and safetywire.

aa. If fast-shutdown valve inlet line was disconnected, install new seal and reinstall line. Torque bolts to 41-45 in-lb, and safetywire.

ab. Secure pneumatic checkout console if no further drying is to be performed (paragraph 3.5.8.17).

3.5.8.10 Drying Heat Exchanger Oxidizer Supply Line.

a. Prepare pneumatic checkout console (paragraph 3.5.8.1).

NOTE

Pneumatic supply to the engine pneumatic system is not required.

b. Prepare vacuum pump. (See figure 3-59.)

c. Disconnect heat exchanger oxidizer supply line from oxidizer pump outlet duct. Remove and retain seal. Immediately install protective closure on duct opening.

d. Install test plate 9026871 from kit 9019968 on heat exchanger oxidizer supply line. Torque bolts to 48-54 in-lb.

e. Using a tee fitting, gage, shutoff valve (figure 3-59), and line, connect vacuum pump to test plate. Make sure shutoff valve is open.

f. Connect shutoff valve and pressure hose from 0-100 PSI SUPPLY OUTLET on pneumatic checkout console to tee on test plate. Make sure shutoff valve is closed.

g. Measure temperature on or near oxidizer line. Record temperature and see figure 1-14 for required vacuum.

h. Draw a vacuum on oxidizer line until required vacuum condition is obtained.

i. Maintain required vacuum condition for 30 minutes.

j. Close shutoff valve in vacuum line and shut off vacuum pump.

k. Open shutoff valve in pressure line, and adjust regulator on PNEUMATIC SUPPLY PANEL (0-100) to 2 psig maximum to backfill oxidizer line with helium.

l. Close shutoff valve; then decrease pressure on PNEUMATIC SUPPLY PANEL (0-100) to zero and vent.

NOTE

Removal of pressure and vacuum lines and test plates and installation of oxidizer line must be completed as soon as possible to minimize contamination by moisture.

m. Disconnect pressure and vacuum lines and remove test plate.

n. Remove protective closure from oxidizer duct. Using new seal, connect heat exchanger oxidizer supply line to oxidizer pump outlet duct. Torque bolts to 48-54 in-lb, and safetywire.

o. If no further drying is to be performed, secure test equipment. Secure pneumatic checkout console. (Refer to paragraph 3.5.8.17.)

3.5.8.11 Drying Oxidizer Tank Pressurization Customer-Connect Line.

a. Prepare pneumatic checkout console (paragraph 3.5.8.1).

NOTE

Pneumatic supply to the engine pneumatic system is not required.

b. Prepare vacuum pump. (See figure 3-59.)

CAUTION

Torque loads applied to the diffuser can damage the burst diaphragm.

c. Remove burst diaphragm on test plate 9020528 from test plate kit 9020266. Install plug on test plate.

d. Remove closure, and install test plate on OXIDIZER TANK PRESSURIZATION customer connect line.

e. Using a tee fitting, connect a pressure hose from 0-100 PSI SUPPLY OUTLET on pneumatic checkout console and from vacuum pump to test plate 9020528. Install shutoff valves (figure 3-59) between vacuum pump and tee (vacuum line) and pneumatic checkout console and tee (pressure line).

f. Make sure shutoff valve in vacuum line is open and shutoff valve in pressure line is closed.

g. See figure 1-14 for required vacuum and draw a vacuum on oxidizer tank pressurization line until required vacuum condition is obtained.

h. Maintain required vacuum condition for a minimum of 30 minutes.

i. Close shutoff valve in vacuum line and shut off vacuum pump.

j. Open shutoff valve in pressure line, and adjust regulator on PNEUMATIC SUPPLY PANEL (0-100) to 2 psig maximum to backfill oxidizer tank pressurization line with helium.

k. Close shutoff valve; then decrease pressure on PNEUMATIC SUPPLY PANEL (0-100) to zero and vent.

NOTE

Removal of pressure and vacuum lines and test plate and installation of protective closure must be completed as soon as possible to minimize contamination by moisture.

l. Disconnect pressure and vacuum lines and test plate from OXIDIZER TANK PRESSURIZATION customer connect line. Install protective closure.

m. Remove plug from test plate 9020528 and install burst diaphragm. (Refer to R-3825-5.)

n. If no further drying is to be performed, secure test equipment. Secure pneumatic checkout console (paragraph 3.5.8.17).

3.5.8.12 <u>Drying Purge Manifold System.</u>

a. Prepare pneumatic checkout console (paragraph 3.5.8.1).

NOTE

Pneumatic supply to the engine pneumatic system is not required to dry the purge manifold.

b. Remove the following engine closures:

(1) Thrust chamber exit closure. (Allow closure to partially cover exit.)

(2) Fuel turbine seal drain.

(3) Oxidizer turbine seal drain.

c. Install test plate 9020222-11 from plate kit 9018843-11 on PURGE MANIFOLD SYSTEM customer connect.

d. Use a tee fitting and connect pressure hoses from 0-1,000 PSI SUPPLY OUTLET and 0-600 PSI MONITOR INLET on pneumatic checkout console to test plate 9020222-11.

e. Remove plug from fitting in fuel pump drain line.

f. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to 80-85 psig as indicated on PNEUMATIC MONITOR PANEL (0-600).

g. Continue purge until indicated humidity of exhaust gases at fuel pump drain line boss and at fuel and oxidizer turbine seal drains (2 places) are within limits of figure 1-13. Check humidity by taping a plastic bag over each outlet. Cut a hole in plastic bags and insert humidity and temperature sensor. Do not allow sensor to touch walls of drain lines or boss. Vent plastic bag to atmosphere.

h. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-1,000) to zero. Remove plastic bags and humidity and temperature measuring equipment from drain line. Reinstall plug and seal in fitting in fuel pump drain line. Torque plug to 65-70 in-lb. Refer to R-3825-5 for handling and installing (Naflex) seals.

i. Remove pressure hoses and test plate from PURGE MANIFOLD SYSTEM customer connect. Install protective closure.

j. Remove humidity indicator, and install protective closures removed in step b.

k. Secure pneumatic checkout console if no further drying is to be performed (paragraph 3.5.8.17).

3.5.8.13 Drying Engine Pneumatic System. The following procedure is used to dry the oxidizer dome, GG oxidizer injector and pneumatic system. Helium regulator actuations performed during the following procedure must be recorded.

NOTE

When drying the pneumatic system to purge the system of gases used in previous operations, perform steps a, b, and m through t.

a. Prepare pneumatic and electrical consoles (paragraph 3.5.8.1).

b. Remove the following engine closures:

(1) Thrust chamber exit closure. (Allow closure to partially cover exit.)

(2) Oxidizer pump seal drain.

(3) Oxidizer turbine seal drain.

(4) Intermediate seal purge.

c. Install humidity and temperature sensor inside thrust chamber at injector. Do not allow sensor to touch injector or thrust chamber walls. Plate indicator as close as possible to thrust chamber exit to permit switching from humidity to temperature measurement.

Operation	Result
d. Position the following switches on electrical control console to ON:	
(1) HELIUM CONTROL on ENGINE TEST/MONITOR panel.	HELIUM CONTROL light comes on.
(2) MAINSTAGE CONTROL on ENGINE TEST/MONITOR panel.	MAINSTAGE CONTROL light comes on.

WARNING

Failure to observe safety requirements of step e can result in injury to personnel.

e. Clear personnel from immediate area of engine or make sure personnel stand behind adequate safety barriers. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-3,000) to 375-425 psig.

Operation	Result
f. Position MAINSTAGE CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	MAINSTAGE CONTROL light goes off.

g. Adjust pressure on PNEUMATIC SUPPLY PANEL (0-3,000) to 225-250 psig. When system has vented to 225-250 psig, personnel may enter area.

h. Continue purge until indicated humidity is within limits of figure 1-13.

Operation	Result
i. Position the following switches on electrical checkout console to ON:	
(1) IGNITION PHASE CONTROL on ENGINE TEST/MONITOR panel.	IGNITION PHASE CONTROL light comes on.
(2) START TANK DISCHARGE CONTROL on ENGINE TEST/MONITOR panel.	START TANK DISCHARGE CONTROL light comes on.
(3) MAINSTAGE CONTROL on ENGINE TEST/MONITOR panel.	MAINSTAGE CONTROL light comes on.
j. Position the following switches on electrical checkout console to OFF:	
(1) MAINSTAGE CONTROL on ENGINE TEST/MONITOR panel.	MAINSTAGE CONTROL light goes off.
(2) START TANK DISCHARGE CONTROL on ENGINE TEST MONITOR panel.	START TANK DISCHARGE CONTROL light goes off.
(3) IGNITION PHASE CONTROL on ENGINE TEST/MONITOR panel.	IGNITION PHASE CONTROL light goes off.
k. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-3,000) to zero. When helium tank pressure has vented, return HELIUM CONTROL switch to OFF.	HELIUM CONTROL light goes off.

l. If nitrogen is being used, vent and disconnect gaseous nitrogen supply from pneumatic checkout console. If helium is being used, proceed to step s.

m. Supply a minimum of 1,000 psig helium pressure to pneumatic checkout console.

Operation	Result
n. Position the following switches on electrical checkout console to ON:	
(1) HELIUM CONTROL on ENGINE TEST/MONITOR panel.	HELIUM CONTROL light comes on.
(2) IGNITION PHASE CONTROL on ENGINE TEST/MONITOR panel.	IGNITION PHASE CONTROL light comes on.
(3) START TANK DISCHARGE CONTROL on ENGINE TEST/MONITOR panel.	START TANK DISCHARGE CONTROL light comes on.
(4) MAINSTAGE CONTROL on ENGINE TEST/MONITOR panel.	MAINSTAGE CONTROL light comes on.
o. Adjust pressure on PNEUMATIC SUPPLY panel (0-3,000) to 225-250 psig.	
p. Position the following switches on electrical checkout console to OFF:	
(1) MAINSTAGE CONTROL on ENGINE TEST/MONITOR panel.	MAINSTAGE CONTROL light goes off.
(2) START TANK DISCHARGE CONTROL on ENGINE TEST/MONITOR panel.	START TANK DISCHARGE CONTROL light goes off.
(3) IGNITION PHASE CONTROL on ENGINE TEST/MONITOR panel.	IGNITION PHASE CONTROL light goes off.
q. Decrease pressure on PNEUMATIC SUPPLY PANEL (0-3,000) to zero.	
r. When helium tank pressure has vented, position HELIUM CONTROL switch on ENGINE TEST/MONITOR panel to OFF.	HELIUM CONTROL light goes off.
s. Remove humidity and temperature measuring equipment from thrust chamber (if used), and install closures removed in step b.	
t. Secure pneumatic and electrical consoles if no further drying is to be performed (paragraph 3.5.8.17).	

3.5.8.14 Drying Propellant and Oxidizer Turbine Bypass Valves. The MFV, MOV, OTBV, MRCV, and GG control valve, including the equalization line, are vacuum dried. The valves may be dried individually or vacuum lines connected between the valves and the valves dried simultaneously.

a. Prepare pneumatic checkout console (paragraph 3.5.8.1).

NOTE

Pneumatic supply to the engine pneumatic system is not required.

b. Prepare vacuum pump. (See figure 3-59.)

CAUTION

Torque loads applied to the diffuser can damage the burst diaphragm.

c. (Deleted)

d. Remove vent port check valve from GG control valve adjustment plate and install MRCV and GG valve drying and leak test kit EWR230004 in vent port. Torque universal fitting bolt EWR168313 to 18-22 in-lb.

e. Using a tee fitting, connect a pressure hose from 0-100 PSI SUPPLY OUTLET on pneumatic checkout console and from vacuum pump to housing EWR168312 or MRCV and GG valve drying and leak test kit EWR230004. Install shutoff valves (figure 3-59) between vacuum pump and tee (vacuum line) and pneumatic checkout console and tee (pressure line).

f. Make sure shutoff valve in vacuum line is open and shutoff valve in pressure line is closed.

g. Determine temperature of valve (stabilized ambient temperature in engine area is acceptable) and see figure 1-14 for required vacuum.

h. Draw a vacuum on valve cavity until vacuum gage indicates required vacuum as determined from figure 1-14. Maintain required vacuum for a minimum of 30 minutes.

i. Close shutoff valve in vacuum line and shut off vacuum pump.

j. Open shutoff valve in pressure line, and adjust regulator on PNEUMATIC SUPPLY PANEL (0-100) to 2 psig maximum to backfill valve cavity with helium.

k. Close shutoff valve; then decrease pressure on PNEUMATIC SUPPLY PANEL (0-100) to zero and vent.

NOTE

Removal of pressure and vacuum lines and adapter and installation of vent port check valve must be completed as soon as possible to minimize contamination by moisture.

l. Disconnect pressure and vacuum lines and adapter.

m. Install vent port check valve on GG control valve. (Refer to R-3825-3.)

n. Remove vent port check valve from linkage housing of OTBV.

o. Repeat steps e through l.

p. Install vent port check valve on OTBV. (Refer to R-3825-3.)

q. Remove vent port check valve from linkage housing of MFV.

r. Repeat steps e through l.

s. Install vent port check valve on MFV. (Refer to R-3825-3.)

t. Remove vent port check valve from linkage housing of MOV.

u. Repeat steps e through l.

v. Install vent port check valve on MOV. (Refer to R-3825-3.)

vA. On engines incorporating MD366 or MD371 change, remove vent port check valve from port A on linkage housing of MRCV, and install adapter fitting into port A. (See figure 3-60A.) Torque adapter fitting to 18-22 in-lb.

vB. Repeat steps e through l.

vC. Remove adapter fitting from port A of MRCV and install vent port check valve. (Refer to R-3825-3.)

w. (Deleted)

x. If no further drying is to be performed, secure test equipment. Secure pneumatic checkout console (paragraph 3.5.8.17).

3.5.8.15 Vacuum-Drying Calips Checkout Line.

a. Prepare pneumatic checkout console (paragraph 3.5.8.1).

NOTE

Pneumatic supply to the engine pneumatic system is not required.

b. Prepare vacuum pump. (See figure 3-59.)

c. Using a tee fitting, connect a pressure hose from 0-100 PSI SUPPLY OUTLET on pneumatic checkout console and from vacuum pump to calips checkout line. Install shutoff valves (figure 3-59) between vacuum pump and tee (vacuum line) and pneumatic checkout console and tee (pressure line).

d. Make sure shutoff valve in vacuum line is open and shutoff valve in pressure line is closed.

e. See figure 1-14 for required vacuum and draw a vacuum on calips checkout line until required vacuum is obtained.

f. Maintain required vacuum condition for a minimum of 30 minutes.

g. Close shutoff valve in vacuum line and shut off vacuum pump.

h. Open shutoff valve in pressure line, and adjust regulator on PNEUMATIC SUPPLY PANEL (0-100) to 2 psig maximum to backfill calips checkout line with helium.

i. Close shutoff valve; then decrease pressure on PNEUMATIC SUPPLY PANEL (0-100) to zero and vent.

NOTE

Removal of pressure and vacuum lines and installation of customer connect closure must be completed as soon as possible to minimize contamination by moisture.

j. Disconnect vacuum and pressure lines and install protective closure on CALIPS CHECKOUT LINE customer connect.

k. If no further drying is to be performed, secure test equipment. Secure pneumatic checkout console (paragraph 3.5.8.17).

3.5.8.16 Drying Start Tank Vent-and-Relief Valve Control Cavity.

a. Prepare pneumatic checkout console (paragraph 3.5.8.1).

NOTE

Pneumatic supply to the engine pneumatic system is not required.

b. Prepare vacuum pump. (See figure 3-59.)

CAUTION

Torque loads applied to the diffuser can damage the burst diaphragm.

c. Remove burst diaphragm from test plate 0020223 from test plate kit 0016724. Install plug on test plate.

d. Install test plate 0020223 on engine START TANK VENT VALVE CONTROL customer connect.

e. Using a tee fitting connect a pressure hose from 0-100 PSI SUPPLY OUTLET on pneumatic checkout console and from vacuum pump to test plate 0020223. Install shutoff valves (figure 3-59) between vacuum pump and tee (vacuum line) and pneumatic checkout console and tee (pressure line).

f. Make sure shutoff valve in vacuum line is open and shutoff valve in pressure line is closed.

g. Determine temperature of start tank vent-and-relief valve (stabilized ambient temperature in engine area is acceptable) and see figure 1-14 for required vacuum.

h. Draw a vacuum on engine START TANK VENT VALVE CONTROL customer connect line until required vacuum is obtained.

i. Maintain required vacuum condition for a minimum of 30 minutes.

j. Close shutoff valve in vacuum line and shut off vacuum pump. Turn off and remove heat lamp, and remove temperature monitor.

k. Open shutoff valve in pressure line, and adjust regulator on PNEUMATIC SUPPLY PANEL (0-100) to 2 psig maximum to backfill valve cavity with helium.

l. Close shutoff valve; then decrease pressure on PNEUMATIC SUPPLY PANEL (0-100) to zero and vent.

NOTE

Removal of pressure and vacuum lines and test plate and installation of protective closure must be completed as soon as possible to minimize contamination by moisture.

m. Disconnect pressure and vacuum lines, remove test plate, and install protective closure on START TANK VENT VALVE CONTROL customer connect.

n. Remove plug from test plate 0020223, and reinstall burst diaphragm. (Refer to R-3825-5.)

o. Secure test equipment and pneumatic console (paragraph 3.5.8.17).

3.5.8.17 Securing Pneumatic and Electrical Consoles.

a. Return all switches and circuit breakers to off, neutral, or deenergized position.

b. Deenergize facility electrical power.

c. Disconnect and store all electrical cables, and reinstall closures and dust caps.

d. Vent all pressure from pneumatic checkout console and engine.

e. Turn off and vent facility pneumatic supply.

f. Disconnect and store all hoses and test plates, and reinstall closures and dust caps on pneumatic checkout console.

g. Remove test plate 0020275 from HELIUM TANK FILL customer connect. Install protective closure.

3.5.9 DRYING STAGE-INSTALLED ENGINES. The drying procedures can be used to dry each engine system or the complete engine system, as required. When drying the complete engine system, the drying sequence requirements of section I must be observed. When drying engine, record all actuations and deactuations of helium regulator, and pressure level of each operation, in Engine Log Book, Helium Regulator Assembly Operation Record. Connections disturbed during engine drying procedures must be leak tested during subsequent engine leak and function testing. Air conforming to the requirements of MSFC-PROC-404 is an acceptable alternate-drying agent for gaseous nitrogen. When one or both of the following conditions exist, personnel must stand behind adequate safety barriers or at a safe distance from engine:

(1) More than 1,600 psig is supplied to engine helium tank.

(2) More than 250 psig is supplied to engine helium tank when engine helium control valve is energized (not required at KSC).

3.5.9.1 Drying Thrust Chamber Jacket.

a. Connect a pneumatic source capable of supplying 60 psig helium or 200 psig gaseous nitrogen (refer to section II) to thrust chamber jacket purge system. Gas temperature must be 50° to 200° F.

b. Remove one desiccant cover from thrust chamber exit closure.

c. Install a hygrometer sensing element, capable of measuring and indicating 5 percent relative humidity, at open thrust chamber exit closure desiccant container.

NOTE

The sensing element must be positioned in the purge gas flow stream.

- If the hygrometer does not incorporate temperature sensing capability, a temperature measuring device accurate within 2° F must be placed in the purge gas flow stream.

d. Apply 40-60 psig helium or 150-200 psig gaseous nitrogen to thrust chamber jacket purge system. Purge for 5 minutes minimum. Continue purge until humidity monitor at thrust chamber exit is within limits of figure 1-13.

e. Decrease purge pressure to zero.

f. Remove humidity indicator, and immediately install thrust chamber exit closure desiccant cover.

g. Disconnect pneumatic supply from thrust chamber jacket purge system.

3.5.9.2 Drying Fuel System (SIVB-Stage Engines).

a. Connect a regulated supply of helium or gaseous nitrogen (refer to section II) capable of supplying 30 psig to instrumentation port on fuel inlet duct downstream of pre-valve.

b. Open instrumentation port on stage fuel recirculation return line.

c. Install humidity indicator on instrumentation port as follows:

(1) Place sensing element inside a plastic bag through open end of bag.

(2) Tape open end of bag over instrumentation port allowing for a vent opening around sensing element. Do not allow sensing element to contact connection or line and do not allow tape to touch sealing surfaces.

(3) Cut a small hole in closed end of bag.

NOTE

The bag must be vented to atmosphere at both ends.

d. Make sure stage recirculation return line valve is closed.

e. Make sure stage fuel pre-valve is closed.

f. Slowly apply 25-30 psig of helium or gaseous nitrogen at 50° to 200° F to inlet duct instrumentation port.

g. Purge for 15 minutes minimum. Continue purge until humidity monitored at fuel recirculation return line instrumentation port is within limits of figure 1-13.

NOTE

Moisture content in stage fuel tank must be within limits of figure 1-13 to obtain engine fuel system humidity limits.

h. Decrease pressure to fuel inlet duct instrumentation port to zero.

i. Remove humidity indicator from stage fuel recirculation return line instrumentation port.

j. Remove one desiccant cover from thrust chamber closure. Install humidity sensing element in desiccant compartment. Do not allow sensing element to contact closure.

k. Remove closures from oxidizer turbine seal drain, oxidizer turbopump primary seal drain, and intermediate seal purge check valve.

l. Verify that pressure in fuel inlet duct is not greater than 5 psig and that pre-valve is closed. Make sure stage recirculation valve is closed.

CAUTION

Opening the MFV with the stage fuel tank pressurized and the fuel pre-valve open or with more than 5 psig in the fuel inlet duct with the pre-valve closed can damage the fuel flowmeter by dry-spinning in excess of 60 seconds.

m. Energize helium control, ignition stage control, and mainstage control valves.

n. Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,000 psig at KSC.

o. Slowly apply 25-30 psig at 50° to 200° F to fuel inlet duct. Do not exceed a maximum total flowrate of 70 scfm helium or 23 scfm gaseous nitrogen through fuel flowmeter.

Operation	Result
p. Monitor fuel inlet duct pressure during drying procedure. If pressure is indicated, shut off and vent purge supply.	No positive pressure indication should be noted.

q. Purge for 5 minutes minimum. Sample moisture content at thrust chamber exit cover desiccant access opening. Continue purge until moisture is within limits of figure 1-13.

r. Decrease purge pressure to fuel inlet duct to zero.

s. Deenergize ignition phase control and mainstage control valves.

t. Allow pressure to vent from helium tank; then deenergize helium control valve.

u. Disconnect purge source from fuel inlet duct and cap port.

v. Remove humidity indicator from thrust chamber closure desiccant compartment. Install new desiccant (refer to section II), and reinstall access cover.

w. Reinstall protective closures.

3.5.9.3 Drying Fuel System (SII-Stage Engines).

a. Connect a regulated supply of helium or gaseous nitrogen (refer to section II) capable of supplying 30 psig to stage LH_2 purge disconnect.

b. Open instrumentation port on fuel inlet duct downstream of pre-valve.

c. Install humidity indicator or instrumentation port as follows:

(1) Place sensing element inside a plastic bag through open end of bag.

(2) Tape open end of bag over instrumentation port allowing for a vent opening around sensing element. Do not allow sensing element to contact connection or line, and do not allow tape to touch sealing surfaces.

(3) Cut a small hole in closed end of bag.

NOTE

The bag must be vented to atmosphere at both ends.

d. Make sure stage recirculation pump and LH_2 return line valves are closed.

e. Make sure stage fuel pre-valve is closed.

f. Slowly apply 25-30 psig of helium or gaseous nitrogen at 50° F to 200° F to stage LH_2 purge disconnect.

g. Purge for 15 minutes minimum. Continue purge until humidity monitored at fuel inlet duct instrumentation port downstream of pre-valve is within limits of figure 1-13.

h. Decrease pressure to stage LH_2 purge disconnect to zero.

i. Remove pressure source from stage LH_2 purge disconnect.

j. Remove humidity indicator from fuel inlet duct instrumentation port.

k. Connect a regulated source of helium or gaseous nitrogen capable of supplying 30 psig to fuel inlet duct instrumentation port downstream of pre-valve.

l. Remove one desiccant cover from thrust chamber closure. Install humidity sensing element in desiccant compartment. Do not allow sensing element to contact closure.

m. Remove closures from oxidizer turbine seal drain, oxidizer turbopump primary seal drain, and intermediate seal purge check valve.

n. Make sure that fuel turbopump inlet duct pre-valve, stage recirculation valve, and stage LH_2 return line valve are closed and that pressure in fuel inlet duct is not greater than 5 psig.

CAUTION

Opening the MFV with the stage fuel tank pressurized and the fuel pre-valve open or with more than 5 psig in the fuel inlet duct with the pre-valve closed can damage the fuel flowmeter by dry-spinning in excess of 60 seconds.

o. Energize helium control, ignition stage control, and mainstage control valves.

p. Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,600 psig at KSC.

q. Slowly apply 25-30 psig at 50° to 200° F to fuel inlet duct. Do not exceed a maximum total flowrate of 70 scfm helium or 23 scfm gaseous nitrogen through fuel flowmeter.

Operation	Result
r. Monitor fuel inlet duct pressure during drying procedure. If pressure is indicated, shut off and vent purge supply.	No positive pressure indication should be noted.

s. Purge for 5 minutes minimum. Sample moisture content at thrust chamber exit cover desiccant access opening. Continue purge until moisture is within limits of figure 1-13.

t. Decrease purge pressure at fuel duct to zero.

u. Deenergize ignition phase control and mainstage control valves.

v. Allow all pressure to vent from helium tank; then deenergize helium control valve.

w. Disconnect purge source from fuel inlet duct and cap port.

x. Remove humidity indicator from thrust chamber closure desiccant compartment. Install new desiccant (refer to section II), and reinstall access cover.

y. Reinstall protective closures.

3.5.9.4 Drying Oxidizer System (SIVB-Stage Engines).

a. Connect a regulated supply of helium or gaseous nitrogen (refer to section II) capable of supplying 30 psig to oxidizer inlet duct instrumentation port downstream of pre-valve.

b. Open instrumentation port on stage oxidizer recirculation return line.

c. Install humidity indicator on instrumentation port as follows:

(1) Place sensing element inside a plastic bag through open end of bag.

(2) Tape open end of bag over instrumentation port allowing for a vent opening around sensing element. Do not allow sensing element to contact connection or line, and do not allow tape to touch sealing surfaces.

(3) Cut a small hole in closed end of bag.

NOTE

The bag must be vented to atmosphere at both ends.

d. Make sure stage oxidizer pre-valve and stage recirculation oxidizer return line valve are closed.

e. Slowly apply 25-30 psig of helium or gaseous nitrogen at 50° to 200° F to oxidizer inlet duct.

f. Purge for 15 minutes minimum. Continue purge until humidity monitored at stage recirculation return line instrumentation port is within limits of figure 1-13.

NOTE

Moisture content in stage oxidizer tank must be within limits of figure 1-13 to obtain engine oxidizer system humidity limits.

g. Decrease pressure to oxidizer inlet duct to zero.

h. Remove humidity indicator from stage recirculation return line port. Cap port.

i. Remove one desiccant cover from thrust chamber closure. Install humidity sensing element in desiccant compartment. Do not allow sensing element to contact closure.

j. Remove closures from oxidizer turbine seal drain, oxidizer turbopump primary seal drain, and intermediate seal purge check valve.

k. Make sure that stage oxidizer pre-valve and stage recirculation valve are closed and that pressure in oxidizer inlet duct is not greater than 5 psig.

CAUTION

Opening the MOV with the stage oxidizer tank pressurized and the oxidizer pre-valve open or with more than 5 psig in the oxidizer inlet duct with the pre-valve closed can damage the oxidizer flowmeter by dry-spinning in excess of 60 seconds.

l. Energize helium control, ignition stage control, and mainstage control valves.

m. Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,000 psig at KSC.

n. Slowly apply 25-30 psig at 50° to 200° F to oxidizer inlet duct. Do not exceed a maximum total flowrate of 35 scfm helium or 12 scfm gaseous nitrogen through oxidizer flowmeter.

Operation	Result
o. Monitor oxidizer inlet duct pressure during drying procedure. If pressure is indicated, shut off and vent purge supply.	No positive pressure indication should be noted.

p. Purge for 5 minutes minimum. Sample moisture content at thrust chamber exit cover desiccant access opening. Continue purge until moisture is within limits of figure 1-13.

q. Deenergize mainstage control valve.	ASI valve will open.

r. Purge through ASI valve until moisture content measured at thrust chamber exit cover desiccant access opening is within limits of figure 1-13.

s. Decrease purge pressure to oxidizer inlet duct to zero.

t. Deenergize ignition phase control valve.

u. Allow all pressure to vent from helium tank; then deenergize helium control valve.

v. Disconnect purge source from oxidizer inlet duct and cap port.

w. Remove humidity indicator from thrust chamber closure desiccant compartment. Install new desiccant (refer to section II), and reinstall access cover.

x. Reinstall protective closures.

3.5.9.5 Drying Oxidizer System (SII-Stage Engines).

a. Connect a regulated supply of helium or gaseous nitrogen (refer to section II) capable of supplying 30 psig to stage recirculation oxidizer return line helium supply disconnect.

b. Open instrumentation port on oxidizer inlet duct downstream of pre-valve.

c. Install humidity indicator on instrumentation port as follows:

(1) Place sensing element inside a plastic bag through open end of bag.

(2) Tape open end of bag over instrumentation port allowing for a vent opening around sensing element. Do not allow sensing element to contact connection or line, and do not allow tape to touch sealing surfaces.

(3) Cut a small hole in closed end of bag.

NOTE

The bag must be vented to atmosphere at both ends.

d. Make sure stage oxidizer pre-valve and stage recirculation oxidizer return line valve are closed.

e. Slowly apply 25-30 psig of helium or gaseous nitrogen at 50° to 200° F to helium supply disconnect.

f. Purge for 15 minutes minimum. Continue purge until humidity monitored at oxidizer inlet duct instrumentation port downstream of pre-valve is within limits of figure 1-13.

g. Decrease pressure to helium supply disconnect to zero.

h. Remove pressure source from helium supply disconnect, and reconnect customer connect line.

i. Remove humidity indicator from oxidizer inlet duct instrumentation port.

j. Remove cap or plug and connect a regulated source of helium or gaseous nitrogen supply capable of supplying 30 psig to oxidizer inlet duct instrumentation port downstream of pre-valve.

k. Remove one desiccant cover from thrust chamber closure. Install humidity sensing element in desiccant compartment. Do not allow sensing element to contact closure.

l. Remove closures from oxidizer turbine seal drain, oxidizer turbopump primary seal drain, and intermediate seal purge check valve.

m. Make sure that stage oxidizer pre-valve and stage recirculation valve are closed and that pressure in oxidizer inlet duct is not greater than 5 psig.

CAUTION

Opening the MOV with the stage oxidizer tank pressurized and the oxidizer pre-valve open or with more than 5 psig in the oxidizer inlet duct with the pre-valve closed can damage the oxidizer flowmeter by dry-spinning in excess of 60 seconds.

n. Energize helium control, ignition stage control, and mainstage control valves.

o. Pressurize engine helium tank to 225-250 psig at stage static-test sites or to 600-1,000 psig at KSC.

p. Slowly apply 25-30 psig at 50° to 200° F to oxidizer inlet duct. Do not exceed a maximum total flowrate of 35 scfm helium or 12 scfm gaseous nitrogen through oxidizer flowmeter.

Operation	Result
q. Monitor oxidizer inlet duct pressure during drying procedure. If pressure is indicated, shut off and vent purge supply.	No positive pressure indication should be noted.

r. Purge for 5 minutes minimum. Sample moisture content at thrust chamber exit cover desiccant opening. Continue purge until moisture is within limits of figure 1-13.

Operation	Result
s. Deenergize main-stage control valve.	ASI valve will open

t. Purge through ASI valve until moisture content measured at thrust chamber exit cover desiccant access opening is within limits of figure 1-13.

u. Decrease purge pressure at oxidizer inlet duct to zero.

v. Deenergize ignition phase control valve.

w. Allow all pressure to vent from helium tank; then deenergize helium control valve.

x. Disconnect purge source from oxidizer inlet duct and cap port.

y. Remove humidity indicator from thrust chamber closure desiccant compartment. Install new desiccant (refer to section II), and reinstall access cover.

z. Reinstall protective closures.

3.5.9.6 Drying Start Tank System (Engines Not Incorporating MD254 or MD347 Change). When performing this procedure, the following purge sequence must be observed: (1) start tank liquid refill line, (2) start tank gaseous refill line, and (3) start tank initial fill line.

NOTE

Steps a through p purge-dry the start system.

a. Disconnect start tank liquid refill line at flange connection to ASI lower fuel line. Remove and retain seal.

b. Install test plate 9025863 from kit 9019968 on start tank refill line. Torque nuts to 61-75 in-lb.

c. Disconnect start tank gaseous refill line at thrust chamber injector fuel manifold. Observe position of bracket 502820 for reinstallation. Remove and retain seal.

d. Install test plate 9025871 from kit 9019968 on start tank gaseous refill line. Torque nuts to 61-75 in-lb.

e. Disconnect START TANK INITIAL FILL customer-connect line.

f. Install test plate 9020274 from kit 9017273 on START TANK INITIAL FILL customer connect. Torque nuts to 61-75 in-lb.

g. Disconnect START TANK VENT & RELIEF VALVE DRAIN customer-connect line.

h. Install a hygrometer sensing element capable of measuring and indicating 5 percent relative humidity at START TANK VENT & RELIEF VALVE DRAIN customer-connect flange as follows:

(1) Place sensing element inside a plastic bag through open end of bag.

(2) Tape open end of bag over START TANK VENT & RELIEF VALVE DRAIN customer-connect flange allowing for a vent opening around sensing element. Do not allow sensing element to contact customer connect flange or line, and do not allow tape to touch sealing surface of flange.

NOTE

The sensing element must be positioned in the purge gas flow stream between the start tank vent-and-relief valve drain flange and the vent opening at the top (open end) of the plastic bag.

- If the hygrometer does not incorporate temperature sensing capability, a temperature measuring device accurate to 2° F must be placed in the purge gas flow stream.

(3) Cut a small hole in closed end of bag.

NOTE

The bag must be vented to atmosphere at both ends.

i. Connect a regulated supply of helium (refer to section II) capable of supplying 50 ±5 psig to test plate on start tank liquid refill line. Helium supply gas temperature must be 50° to 200° F at purge inlet.

j. Apply 550 psia maximum pneumatic pressure to START TANK VENT VALVE CONTROL customer connect to open vent valve.

k. Adjust pressure to test plate to 50 ±5 psig, and purge with helium until humidity is within limits of figure 1-13. Continue purging for 2 more hours; then decrease purge pressure to zero.

l. Decrease pressure to START TANK VENT VALVE CONTROL customer connect to zero.

m. Disconnect purge line from test plate, and immediately install protective cap on test plate.

n. Perform steps i through m on start tank gaseous refill line and then on start tank initial fill line.

o. Do not remove test plates. The test plates will be used in the vacuum-drying procedure (steps q through az).

p. Remove sensing element and bag from START TANK VENT & RELIEF VALVE DRAIN customer connect.

NOTE

Steps q through az vacuum-dry the start system.

q. Install test plate 9020222-11 from kit 9018843-11 on START TANK VENT & RELIEF VALVE DRAIN customer connect. Torque bolts to 61-75 in-lb.

NOTE

If MD330 change was accomplished (replacement of STDV) after stage acceptance test, disregard steps r through w and proceed to step x.

r. Remove bolts and washers that secure STDV discharge hose to STDV. Disconnect hole and remove seal. Secure hose, as necessary, to support hose and to obtain clearance to install test plate.

s. Install protective cover on open flange of STDV discharge hose.

t. Install spacer EWR129666 between STDV swing gate and gate sealing surface. Be extremely careful to prevent damage to sealing surfaces.

u. Obtain test plate 9022752 and the following from STDV adapter set 9022750-11:

(1) Eight bolts NAS1006-29A.

(2) Eight washers RD153-5004-0006.

v. Install test plate 9022752 on outlet flange of STDV with bolts and washers from STDV adapter set 9022750. Torque bolts to 252-308 in-lb.

w. Remove bolts and washers that secure drain line to STDV (port E). Install test plate 9025399 from test plate kit 9025400-11 between drain line flange and valve drain port. Be careful to prevent distortion of line. Torque bolts to 41-45 in-lb.

x. Cut lockwire and remove burst diaphragm assemblies from test plates 9020274, 9019968, 9019969, and 9020222-11. Do not disassemble burst diaphragms.

y. Install plugs AN814-6J with packing MS28778-6 in test plates. Lubricate threads and packings with sealing and antiseize compound RB0140-005 (Rocketdyne) before installation. Torque plugs to 80-120 in-lb.

z. Protect burst diaphragm assemblies from contamination and retain for reinstallation.

aa. Connect a line (tubing or hose) from vacuum manifold 9025820 to each of the following test plates: (Torque fittings to 135-185 in-lb.)

(1) Test plate on start tank liquid refill line.

(2) Test plate on start tank gaseous refill line.

(3) Test plate on START TANK INITIAL FILL customer connect.

(4) Test plate on START TANK VENT & RELIEF VALVE DRAIN customer connect.

(5) Test plate on STDV outlet flange. (Not required if MD336 change has been accomplished following stage acceptance test.)

ab. Connect a vacuum pump capable of obtaining vacuum requirements of figure 1-14 to 1/2-inch-tube fitting on end of vacuum manifold. Torque fitting to 450-525 in-lb. Install a shutoff valve between vacuum pump and vacuum manifold.

ac. Connect a gage, manometer, or equivalent device capable of measuring vacuum requirements of figure 1-14 to 1/4-inch tube fitting on end of vacuum manifold, using one copper seal RE261-3001-0001. Torque fitting to 135-185 in-lb. Vacuum measuring device must be accurate to ±1 millimeter at required vacuum condition. If a differential gage is used, the measured valve must be corrected for the barometric pressure of the location (including altitude) where drying is being done. If vacuum-monitoring device can be damaged by positive pressure, install a shutoff valve between device and vacuum manifold.

ad. Connect a regulated helium supply system capable of supplying 2 psig to open fitting on vacuum manifold, using one copper seal RE261-3001-0001. Torque fitting to 135-185 in-lb. Helium supply system must incorporate a shutoff valve installed as near vacuum manifold as possible.

ae. Using caps AN929-4J and copper seals RE261-3001-0001, cap unused ports on vacuum manifold. Torque caps to 135-185 in-lb.

af. Close shutoff valve in helium supply system (installed near vacuum manifold).

ag. Locate a temperature measuring device accurate within 2° F and capable of measuring ambient temperature on or near vacuum manifold. Record temperature. Temperature must be +60° F or greater for this drying procedure.

ah. Verify that vacuum system can obtain and maintain vacuum requirements of figure 1-14.

ai. Apply 550 psia maximum to START TANK VENT VALVE CONTROL customer connect.

aj. Open shutoff valve installed in vacuum line to pump and initiate vacuum-drying of system. Maintain vacuum for a minimum of 3 hours, which must include drying for a minimum of 1 hour at required vacuum condition (see figure 1-14).

ak. Close shutoff valve in vacuum line to pump, and shut off vacuum pump.

al. Close shutoff valve in vacuum monitor gage line (if installed), open shutoff valve in helium supply system, and pressurize start system to 2 psig.

am. Close shutoff valve in helium supply line near vacuum manifold; then shut off and vent helium supply system.

an. Decrease pressure to START TANK VENT VALVE CONTROL customer connect to zero.

NOTE

During subsequent operations, all openings in the start system must remain capped except when making required connections. Once reassembly of the start system is begun, it must be completed as soon as possible to minimize contamination by moisture.

ao. Disconnect vacuum lines from test plates. Install protective cap on test plate immediately after disconnecting line from each test plate.

ap. Disassemble and remove vacuum hardware from engine area.

aq. Remove test plate from start tank gaseous refill line. Using new seal, connect refill line to thrust chamber injector fuel manifold flange. Using bolts RD111-1000-3428, install bracket 502820 in same location as before removal. Torque bolts to 43-47 in-lb, and safetywire as required.

ar. Remove test plate from start tank liquid refill line. Using new seal, connect refill line to ASI lower fuel line. Torque bolts to 52-58 in-lb, and safetywire.

as. Remove test plate from START TANK INITIAL FILL customer connect. Using new seal, reconnect initial-fill customer connect line.

at. Remove test plate from START TANK VENT & RELIEF VALVE DRAIN customer connect. Using new seal, reconnect vent-and-relief valve drain customer connect line.

CAUTION

During steps au through aw, extreme care must be taken to prevent damage to sealing surfaces.

NOTE

If MD336 change was accomplished (replacement of STDV) after stage acceptance test, disregard steps au through aw and proceed to step ax.

au. Remove test plate from STDV outlet, and carefully remove spacer from between STDV swing gate and gate sealing surface.

av. Remove protective closure from STDV discharge hose, install new seal, and connect hose to STDV with bolts and washers. Torque bolts to 314-346 in-lb, and safetywire.

aw. Remove bolts and washers that secure STDV drain line to STDV, and remove test plate. Install new seal, and connect drain line to STDV with bolts and washers. Torque bolts to 41-45 in-lb, and safetywire.

ax. Remove plugs and packings from test plates 9020274, 9019968, 9019969, and 9020222-11.

ay. Install new packings MS28778-6 lubricated with sealing and antiseize compound RB0140-C05 (Rocketdyne) on burst diaphragms.

az. Reinstall burst diaphragm on test plates. Torque to 100-150 in-lb, and safetywire.

3.5.9.7 Drying Start System (Engines Incorporating MD254 or MD347 Change).

a. Install a hygrometer sensing element capable of measuring and indicating 5 percent relative humidity at start tank vent-and-relief valve drain exit as follows:

(1) Place sensing element inside a plastic bag through open end of bag.

(2) Tape open end of bag over start tank vent-and-relief valve drain exit, allowing for a vent opening around sensing element. Do not allow sensing element to contact flange or line.

NOTE

The sensing element must be positioned in the purge gas flow stream between the start tank vent-and-relief valve drain exit and the vent opening at the top (open end) of the plastic bag.

- If the hygrometer does not incorporate temperature sensing capability, a temperature measuring device accurate within 2° F must be placed in the purge gas flow stream.

(3) Cut a small hole in closed end of bag.

NOTE

The bag must be vented to atmosphere at both ends.

b. Connect a regulated supply of helium (refer to section II) capable of supplying 50 ±5 psig to start tank initial fill line. Helium supply gas temperature must be 50° to 200° F at customer connect.

c. Apply 550 psia maximum pneumatic pressure to START TANK VENT VALVE CONTROL customer connect to open vent valve.

d. Adjust pressure to start tank initial fill to 50 ±5 psig and purge with helium until humidity is within limits of figure 1-13. Continue purging for 2 more hours; then decrease purge pressure to zero.

e. Decrease pressure to START TANK VENT VALVE CONTROL customer connect to zero.

f. Remove sensing element and bag from start tank vent-and-relief valve drain exit.

3.5.9.8 Drying Turbine and Exhaust System.

a. Connect a regulated supply of helium (refer to section II) capable of supplying 500 psig to START TANK INITIAL FILL customer connect.

b. Remove one desiccant cover from thrust chamber closure. (Install humidity sensing element in desiccant compartment with cover partially in place, allowing for purge flow. Do not allow sensing element to contact thrust chamber or closure.

c. Remove closures from oxidizer turbine seal drain, oxidizer turbopump primary seal drain, and intermediate seal purge check valve.

d. Make sure start tank is vented.

CAUTION

Failure to open the STDV before applying purge pressure can result in dry-spinning of the fuel turbine.

e. Energize helium control, ignition stage control, mainstage control, and STDV control valves.

f. Pressurize engine helium tank to 225-250 psig at stage static-test sites, or 600-1,600 psig at KSC.

g. Slowly apply 500 psig maximum of helium at 50° to 500° F to START TANK INITIAL FILL customer connect system.

h. Purge for 15 minutes minimum. Continue purge until humidity monitored at thrust chamber exit is within limits of figure 1-13.

i. Decrease pressure at START TANK INITIAL FILL customer connect system to zero.

j. Deenergize STDV, mainstage, and ignition-phase control valves.

k. Decrease pressure to engine helium tank to zero.

l. Allow all pressure to vent from helium tank; then deenergize helium control valve.

m. Disconnect purge source from START TANK INITIAL FILL customer connect system.

n. Remove humidity indicator from thrust chamber closure desiccant compartment. Install desiccant (refer to section II), and reinstall access cover.

o. Install protective closures.

3.5.9.9 <u>Drying Gas Generator and Propellant Lines.</u>

a. Disconnect mainstage control manifold from GG control valve. Note position of bracket for reinstallation. Remove seal and retain.

NOTE

It may be necessary to remove line clamping or to disconnect mainstage control manifold (inlet line) from fast-shutdown valve to obtain clearance to install test plate on GG control valve.

b. Install test plate 9025853 from kit 9010969 on GG control valve opening control port. Install protective closure on mainstage control manifold. Torque bolts that secure test plate to 41-45 in-lb.

c. Connect a regulated supply of helium (refer to section II) capable of supplying 225-250 psig to test plate on GG control valve.

d. On SII-stage engines, connect a pneumatic source (helium or gaseous nitrogen) capable of supplying 30 psig to stage oxidizer recirculation return line helium injection supply system. Gas temperature must be 50° to 200° F.

e. On SIVB-stage engines, connect a pneumatic source (helium or gaseous nitrogen) capable of supplying 30 psig to an instrumentation port on stage oxidizer recirculation return line. Gas temperature must be 50° to 200° F.

f. Verify that stage oxidizer pr[illegible] and oxidizer recirculation system shutoff valve (LOX return valve on SII stage) are closed.

g. Remove one desiccant cover from thrust chamber exit closure.

h. Install a hygrometer sensing element capable of measuring and indicating 5 percent relative humidity at open thrust chamber exit closure desiccant container.

NOTE

The sensing element must be positioned in the purge gas flow stream.

- If the hygrometer does not incorporate temperature sensing capability, a temperature measuring device accurate within 2° F must be placed in the purge gas flow stream.

i. Adjust pressure to 225-250 psig to open GG control valve.

j. Adjust pressure to stage oxidizer recirculation system to 25-30 psig. Purge until indicated humidity is within limits of figure 1-13. Continue purging for 2 more hours; then decrease purge pressure to zero.

k. Disconnect pneumatic source from stage oxidizer recirculation system, and immediately close system.

l. Connect pneumatic source disconnected in step k to instrumentation port in stage LH_2 recirculation system.

m. Verify that stage LH_2 pre-valve and recirculation system shutoff valve are closed.

n. Adjust pressure to stage LH_2 recirculation system to 25-30 psig. Purge until indicated humidity is within limits of figure 1-13. Continue purging for 2 more hours; then decrease purge pressure to zero.

o. Disconnect pneumatic source from stage LH_2 recirculation system, and immediately close system.

p. Decrease pressure to GG control valve to zero.

q. Remove humidity indicator, and immediately install thrust chamber exit closure desiccant cover.

r. Disconnect pneumatic supply from test plate on GG control valve.

s. Remove test plate from GG control valve.

t. Install new seal, mainstage control manifold, and bracket on GG control port with bolts and washers. Torque bolts to 41-45 in-lb, and safetywire.

u. If the fast-shutdown valve inlet line was disconnected, install new seal and reinstall line. Torque bolts to 41-45 in-lb, and safetywire.

3.5.9.10 Drying Purge Manifold System. This procedure dries the fuel and oxidizer turbopump and cavities and the GG fuel manifold.

a. Connect a regulated supply of helium (refer to section II) capable of supplying 115 psig to purge manifold.

b. Remove closures from fuel and oxidizer turbine seal drains.

c. Remove one desiccant cover from thrust chamber exit closure.

d. Install a hygrometer sensing element capable of measuring and indicating 5 percent relative humidity at open thrust chamber exit closure desiccant container.

NOTE

The sensing element must be positioned in the purge gas flow stream.

- If the hygrometer does not incorporate temperature sensing capability, a temperature measuring device accurate within 2° F must be placed in the purge gas flow stream.

e. Remove plug from fuel turbopump primary seal drain line upstream of check valve.

f. Install a hygrometer sensing element capable of measuring and indicating 5 percent relative humidity at fuel turbopump drain line, fuel turbine seal drain, and oxidizer turbine seal drain as follows:

(1) Place sensing element inside a plastic bag through open end of bag.

(2) Tape open end of bag over drain connections allowing for a vent opening around sensing element. Do not allow sensing element to contact connections or line, and do not allow tape to touch sealing surface of connections.

NOTE

The sensing element must be positioned in the purge gas flow stream between the drain line and the vent opening at the top (open end) of the plastic bag.

- If the hygrometer does not incorporate temperature sensing capability, a temperature measuring device accurate to 2° F must be placed in the purge gas flow stream.

(3) Cut a small hole in closed end of bag.

NOTE

The bag must be vented to atmosphere at both ends.

g. Adjust pressure to purge manifold system to 67-115 psig. Helium temperature must be 50° to 200° F at customer connect.

h. Continue purge until humidity monitored at fuel turbopump primary seal drain is within limits of figure 1-13.

i. Decrease purge pressure to zero.

j. Remove humidity indicator, and reinstall plug at fuel turbopump primary seal drain. Torque plug to 65-70 in-lb. Leak-test plug during remaining purge requirements.

k. Readjust purge pressure to 67-115 psig. Continue purge while monitoring humidity at fuel and oxidizer turbine seal drains until 2 hours of total drying time (including purge of step h) is completed. Discontinue purge if humidity monitored at drains is within limits of figure 1-13.

l. Decrease purge pressure to zero.

m. Remove humidity indicators from drains and install protective closures.

n. Install desiccant compartment cover on thrust chamber closure.

o. Remove purge source from PURGE MANIFOLD SYSTEM customer connect. Connect customer line if disconnected.

p. Safetywire fuel turbopump drain plug.

3.5.9.11 Drying Oxidizer Dome and Gas Generator Oxidizer Injector.

WARNING

Failure to observe safety requirements in step a can result in injury to personnel.

a. Have personnel stand behind adequate safety barriers or at a safe distance from the engine during this task. (Not required at KSC.)

b. Remove one desiccant cover from thrust chamber closure.

c. Remove closures from oxidizer turbopump primary seal drain line, oxidizer turbine seal drain, and intermediate seal purge check valve.

d. Energize helium control valve.

e. Pressurize engine helium tank to 1,400-1,600 psig. Maintain pressure under flow conditions at 50° to 200° F for 15 minutes.

f. Decrease pressure in engine helium tank to zero.

g. When helium tank is vented, deenergize helium control valve.

h. Install desiccant cover on thrust chamber closure.

i. Install closures on turbopump drain lines.

3.5.9.12 Drying Pneumatic System. Pneumatic system drying is required only if system has been opened or otherwise exposed to contamination subsequent to post-acceptance test engine sequence test.

WARNING

Failure to observe safety requirements in step a can result in injury to personnel.

a. Have personnel stand behind safety barriers or at a safe distance from the engine during this task. (Not required at KSC.)

b. Remove one desiccant cover from thrust chamber exit closure.

c. Remove closures from oxidizer turbopump primary seal drain, oxidizer turbine seal drain, and oxidizer turbopump intermediate seal purge check valve.

d. Make sure stage pre-valves are closed and oxidizer and fuel inlet ducts are at ambient pressure to prevent dry spinning of propellant flowmeters when engine propellant valves are opened.

e. Energize helium control valve.

f. Pressurize engine helium tank to 1,400-1,600 psig. Maintain pressure under flow conditions at 50° to 200° F.

g. Energize ignition-phase control valve.

h. Energize mainstage control valve.

i. Energize STDV control valve.

j. Deenergize STDV control valve.

k. Deenergize mainstage control valve.

l. Deenergize ignition-phase control valve.

m. Repeat steps g through l twice.

n. Decrease pressure supply to engine helium tank to zero.

o. When helium tank is vented, deenergize helium control valve.

p. Install desiccant cover on thrust chamber exit closure.

q. Install closures on oxidizer turbopump primary seal drain line, oxidizer turbine seal drain, and intermediate seal purge check valve.

3.5.9.13 Vacuum-Drying Propellant Valves and Oxidizer Turbine Bypass Valve. The accumulation of moisture in the internal cavities of these valves may prevent proper operation of the valves since the moisture freezes when the valves are subjected to low-temperature conditions. The GG control valve, OTBV, MFV, MOV, and MRCV linkage cavities may be dried individually or simultaneously.

a. Remove vent port check valve on GG control valve adjustment plate. (Refer to R-3825-3.)

b. Remove vent port check valve on OTBV linkage housing (port C). (Refer to R-3825-3.)

bA. On engines incorporating MD366 or MD371 change, remove vent port check valve from port A on linkage housing of MRCV (refer to R-3825-3) and install MRCV and GG valve drying and leak test kit EWR230094 into port A of MRCV. (See figure 3-60A.) Torque universal fitting bolt EWR168313 to 18-22 in-lb.

c. Remove vent port check valve on linkage housing of MFV (port G) and MOV (port G).

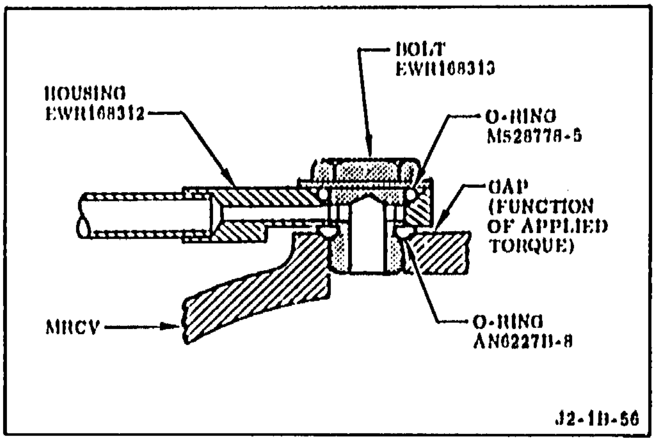


Figure 3-60A. MRCV and GG Valve Drying and Leak Test Kit EWR230094

d. See figure 3-61 and connect vacuum system to valves. Vacuum pump must be capable of obtaining vacuum requirements of figure 1-14. Gage used to measure absolute pressure in system must be accurate to ±1 millimeter at required vacuum condition. If a differential pressure gage is used, the measured value must be corrected for the barometric pressure of the location (including altitude) where drying is being done. Install fittings from kit EWR225309 to interconnect valves. Do not exceed 65 in-lb when installing fittings in engine valves.

e. Determine temperature of valves (stabilized ambient temperature in engine area is acceptable) and see figure 1-14 for required vacuum.

f. Close shutoff valve in helium supply system.

g. Open shutoff valve installed in vacuum line.

h. Draw a vacuum on system until vacuum gage indicates required vacuum as determined from figure 1-14. Maintain required vacuum for a minimum of 30 minutes.

i. Close shutoff valve in vacuum line to pump and shut off vacuum pump.

j. Close shutoff valve in vacuum monitor gage line, open shutoff valve in helium supply system, and pressurize system to 2 psig.

k. Close shutoff valve in helium supply line; then shut off and vent helium supply system.

l. Disconnect lines and fittings from valves.

m. Install vent port check valves. (Refer to R-3825-3.)

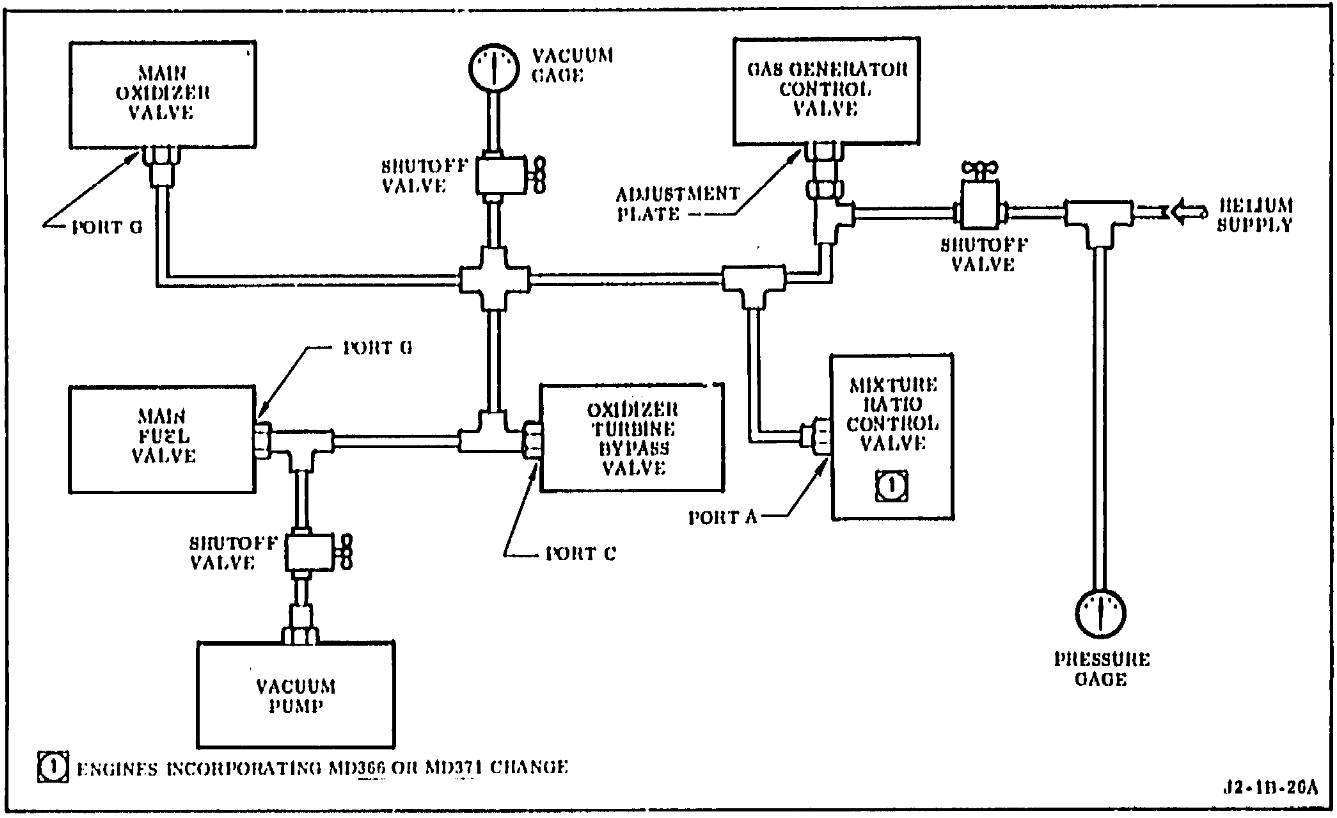


Figure 3-61. Propellant Valves and Oxidizer Turbine Bypass Valve Vacuum Drying Schematic (Typical)

3.5.9.14 Vacuum-Drying Calips Checkout Line.

a. Using a tee fitting, connect a vacuum pump capable of obtaining vacuum requirements of figure 1-14 in system to CALIPS CHECKOUT LINE customer connect. Gage used to measure absolute pressure in system must be accurate to ±1 millimeter at required vacuum condition. If a differential pressure gage is used, the measured value must be corrected for the barometric pressure of the location (including altitude) where drying is being done. Vacuum system must incorporate a shutoff valve between customer connect and vacuum pump.

b. Connect a regulated supply of helium (refer to section II) capable of supplying 2 psig to tee on customer connect. Helium supply system must incorporate a shutoff valve installed as near customer connect as possible.

c. Make sure shutoff valve in vacuum line is open and shutoff valve in pressure line is closed.

d. See figure 1-14 for required vacuum, and initiate vacuum drying of calips checkout line and mainstage OK pressure switches. Maintain required vacuum condition for a minimum of 30 minutes.

e. Close shutoff valve in vacuum line to pump, and shut off vacuum pump.

f. Open shutoff valve in helium supply system, and pressurize system to 2 psig.

g. Close shutoff valve in helium supply line; then shut off and vent helium supply system.

h. Disconnect lines and fitting from customer connect.

i. Immediately install protective closure or reconnect customer connect system.

3.5.9.15 Drying Start Tank Vent-and-Relief Valve Control Cavity. The accumulation of moisture in the control cavity of the start tank vent-and-relief valve may prevent proper operation of the valve due to cryogenic operating temperatures. Moisture may enter the control cavity when the valve control line is opened to atmosphere during engine installation, or moisture may accumulate after repeated engine chill-downs.

a. Using a tee fitting, connect a regulated helium supply capable of supplying 2 psig to start tank vent valve control system. Helium supply system must incorporate a shutoff valve installed as near tee fitting as possible.

b. Connect a vacuum pump, capable of obtaining vacuum requirements of figure 1-14 in vent-and-relief valve control cavity, to tee connected to start tank vent valve control system. Gage used to measure absolute pressure in system must be accurate to ±1 millimeter at required vacuum condition. If a differential pressure gage is used, the measured value must be corrected for the barometric pressure of the location (including altitude) where drying is being done. Vacuum system must incorporate a shutoff valve between tee fitting and vacuum pump.

c. Make sure shutoff valve in vacuum line is open and shutoff valve in pressure line is closed.

d. Determine temperature of start tank vent-and-relief valve (stabilized ambient temperature in engine area is acceptable) and see figure 1-14 for required vacuum.

e. Draw a vacuum on start tank vent valve control line until required vacuum is obtained.

f. Maintain required vacuum for a minimum of 30 minutes.

g. Close shutoff valve in vacuum line to pump and shut off vacuum pump.

h. Open shutoff valve in helium supply system, and pressurize system to 2 psig.

i. Close shutoff valve in helium supply line; then shut off and vent helium supply system.

j. Disconnect drying system lines and tee from vent valve control system.

3.5.9.16 Drying Oxidizer and Fuel Inlet Duct Torsional Bellows. After torsional bellows have been dried, they must be protected from moisture. This is done by installing protective covers specified in R-3825-3.

a. Obtain the following equipment:

(1) Fuel inlet duct heater kit 9016954 consisting of enclosure 9016954-3, heater assembly 9016954-5, and blanket assembly 9016954-7.

(2) Oxidizer inlet duct heater kit 9016955 consisting of enclosure 9016955-3, heater assembly 9016955-5, and blanket assembly 9016955-7.

(3) Multimeter, Triplet 630, or equivalent.

CAUTION

Do not connect heater to electrical power supply until heater and insulator installation is complete. Applying electrical power before heater is centered and installation is completed can damage heater.

- Heater must be installed as specified to prevent damage to heater, and to ensure proper drying of the bellows.

b. Install applicable heater assembly and blanket assembly, specified in step a, on inlet duct as follows:

(1) If inlet duct bellows assembly protective covers RK395-40016 basic, -011, or -021 are installed, remove covers.

(2) Spread heater band only enough to clear diameter of duct flange (heater may be spread across its diameter and along its longitudinal axis). Place heater around flange with center tab between boltheads on bolthead side of flange, and outside tabs positioned with one tab on each side of one bipod set as shown in figure 3-61A. Contour of heater must mate with contour of duct flange, and heater bolt connection must be located between 2 sets of bipods as shown in figure 3-61A.

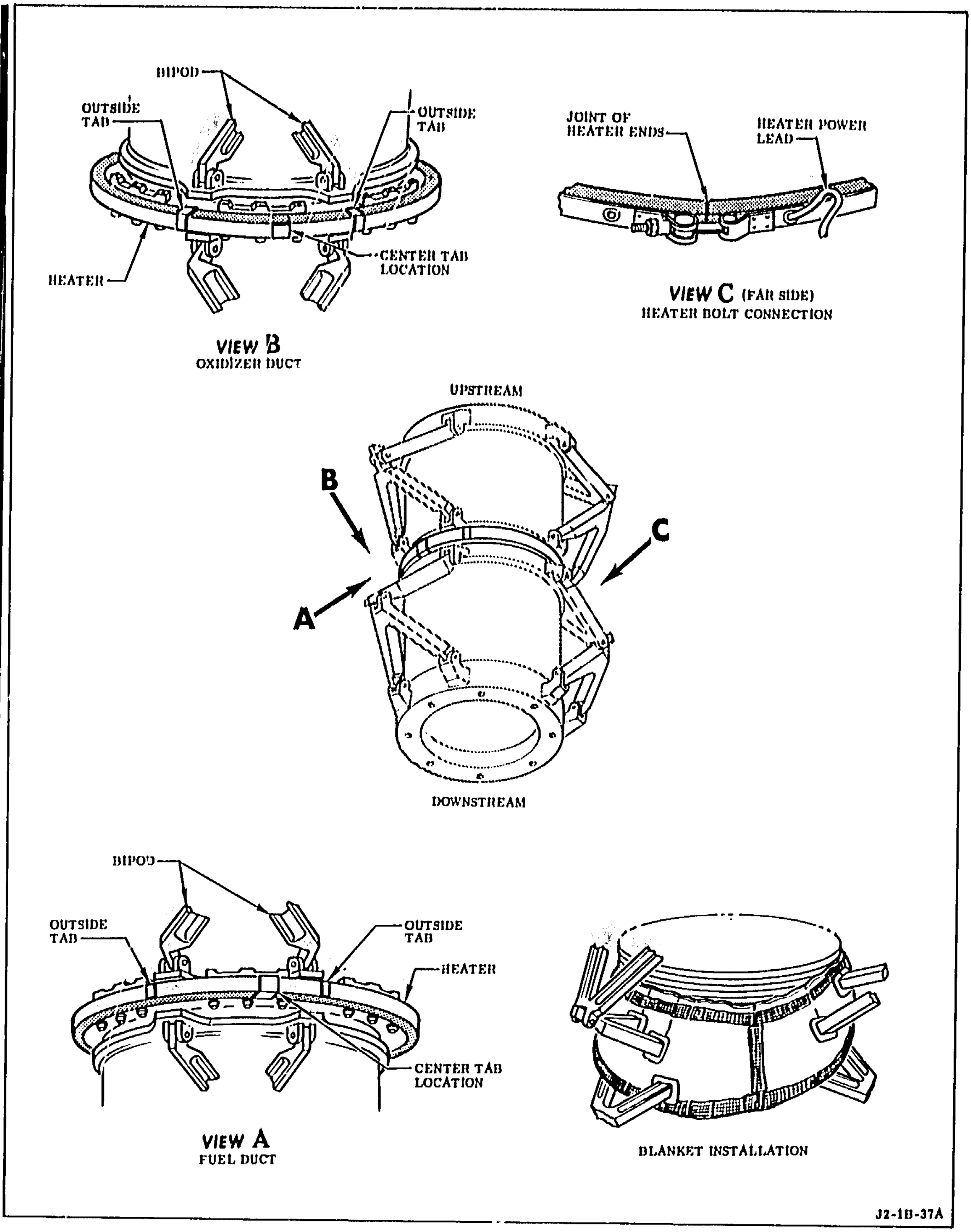


Figure 3-61A. Installing Inlet Duct Torsional Bellows Heater

(3) Center heater band on flange joint, and connect heater ends with connecting bolt as shown in figure 3-61A. Using an 11/32 inch wrench, tighten nut until rubber ends of heater butt against each other. (A 100 percent contact of the end surfaces is not required.)

(4) Using multimeter, perform the following resistance test on heater:

Operation	Result
(a) Pin ϕ (supply) to engine.	Resistance must be greater than 100,000 ohms.
(b) Pin N (return) to engine.	Resistance must be greater than 100,000 ohms.
(c) Pin G (ground) to heater outer band.	Resistance must be less than 1.0 ohm.

(5) Install insulator blanket snugly around heater band, with end of blanket located between 2 sets of bipods as shown in figure 3-61A. Aline cutouts around bipods and secure by pressing blanket tape ends to blanket.

CAUTION

Heater leads must not have any weight or strain placed on them, since damage to heater may result.

c. Connect heater to a 115 vac electrical source (heater is rated at 225 ±5 watts). After approximately 10 minutes, make sure heater is operating by feeling bipods or inlet duct adjacent to insulator for indication of heat.

d. Allow heater to operate continuously for a minimum of 8 hours if ambient temperature is below 50° F, 6 hours if ambient temperature is 50° to 80° F, and 4 hours if ambient temperature is 80° F or above.

WARNING

Touching heater or adjacent flange area, before heater has cooled, may result in injury to personnel.

e. After specified time, disconnect heater from electrical power source, and remove insulator blanket.

f. Allow heater to cool for 1/2 hour minimum; then loosen heater clamp nut, spread heater only enough to clear duct flange, and remove from duct.

g. Place heater assembly and blanket assembly in applicable enclosure specified in step a.

h. Install protective covers on flange joint immediately after completion of drying (refer to R-3825-3).

3.5.10 ACTUATING VENT PORT CHECK VALVES. This task consists of manually actuating all engine vent port check valves before CDDT and within 60 days of launch. All vent port check valves except 553364 have poppets large enough to grip by hand for actuation. Actuate valves 553364 using an adhesive device wrapped around a finger as follows:

a. Wrap a layer of aluminum tape 0425 3UAL 9704M (Minnesota Mining and Mfg), or equivalent, snugly around a finger with sticky side out.

b. Wrap a layer of pressure-sensitive tape RB0195-002 (Rocketdyne) over aluminum tape with sticky side out.

c. Actuate vent port check valve by firmly pressing tape ring against poppet surface and lifting, and/or rotating and then lifting poppet offseat.

3.5.11. REPLACING THRUST CHAMBER TEMPERATURE TRANSDUCER HEAT SINK COMPOUND. This task must be performed 6 months before launch. The task consists of removing the thrust chamber temperature transducer, replacing the heat sink compound between the transducer and transducer mounting pad, and reinstalling the transducer.

a. Without disconnecting electrical connector P120 or P130, remove thrust chamber jacket temperature transducer CS1 or CS1a as follows: (See figure 3-61B.)

(1) Remove bolts and washers that secure temperature transducer to transducer mounting pad.

(2) Remove screws and washers that secure bracket to bracket mounting pad on thrust chamber.

(3) Move transducer away from mounting pads.

WARNING

The following procedure specifies trichloroethylene (MIL-T-27602) or trichloroethane (MIL-T-81533), which are toxic solvents. Inhalation of their vapors or prolonged contact with the liquids can cause serious injury or death.

- The following procedure specifies cleaning compound (MIL-C-81302), which is volatile. Use in a well-ventilated area since the vapors displace the oxygen in the air, resulting in suffocation.

(4) Remove heat-sink compound from transducer and transducer mounting pad. Clean transducer and transducer mounting pad by wiping with clean, lint-free cloth dampened with trichloroethylene, cleaning compound, or trichloroethane.

b. Install thrust chamber jacket temperature transducer CS1 or CS1a as follows: (See figure 3-61B.)

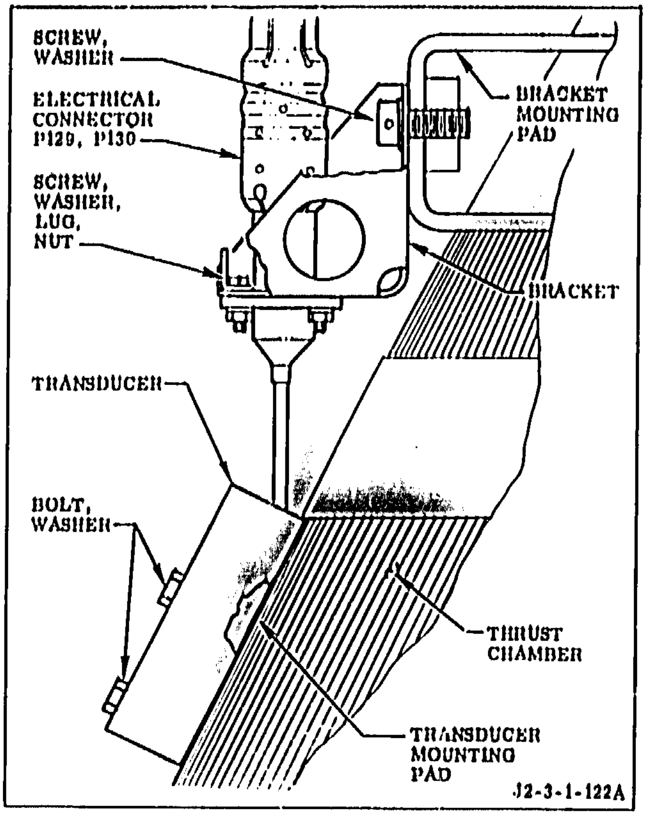


Figure 3-61B. Thrust Chamber Jacket Temperature Transducers

NOTE

There must not be cavities in the compound that could cause air pockets between the transducer and the transducer mounting pad.

(1) Spread an even coat of heat-sink compound DC340 (Dow Corning Corp) in recessed area of transducer so that recessed area is filled from flush to 1/16 inch above mating surface of transducer.

(2) Position and secure transducer to transducer mounting pad with bolts and washers; lubricate (Method A, R-3825-3, Volume I) bolts with lubricant grease RB0140-012 (Rocketdyne). Do not tighten bolts.

(3) Secure bracket to bracket mounting pad with screws and washers. Torque screws to 67-82 in-lb.

(4) Torque bolts securing transducer to transducer mounting pad to 3-5 in-lb and safetywire.

3.6 HANDLING.

3.6.1 ALINING OXIDIZER AND FUEL INLET DUCTS.

The following procedures check the alinement of the oxidizer and fuel inlet duct null point index marks and aline the ducts if misalinement exceeds the specified tolerances:

a. Check applicable inlet duct null-point index marks scribed in 3 places on circumference of duct. Duct alinement is satisfactory if total misalinement of all 3 sets of index marks does not exceed 0.066 inch. If duct alinement is satisfactory, disregard remainder of procedure.

b. If alinement is not satisfactory, obtain null adjuster set 9024540 and aline fuel or oxidizer inlet duct as outlined in steps c through t. (See figure 3-62.) Use null adjuster 9024757 to aline oxidizer duct, and null adjuster 9024767 to aline fuel duct.

c. Cut lockwire, and remove 3 bolts, 3 washers, and nut plate from propellant inlet duct center flange. Mark bolts and washers for reinstallation in same holes.

d. If engine is installed in stage, remove bolts that secure inlet duct to stage.

e. Remove 2 lockpins from null adjuster housing.

f. Remove clevis pin that secures clevis to idler. Remove idler from null adjuster.

g. Loosen thumbscrews until screw end is flush with inside surface of housing.

h. Place idler on side of inlet duct flange with elongated boltholes so that pin engages center bolthole.

i. Place housing over idler and cut flange engaging housing pin in center bolthole of flange.

j. Install pins through null adjuster housing and 2 outside boltholes of inlet duct flange.

NOTE

Idler must be free to slide against thumbscrews.

k. Tighten thumbscrew until idler contacts inlet duct flange.

l. Adjust handle until idler and clevis holes are in alinement. Install clevis pin.

m. Observing index marks through sight hole in null adjuster housing, turn handle until index mark on one ring is beyond mark on other ring. Hold this point for 3-5 minutes; then back-off handle until tension is removed from duct. (Rotation beyond null position is required to release residual stresses and friction.) Repeat this step as necessary to obtain alinement tolerances specified in step a.

n. Remove clevis pin, and unscrew thumbscrews until they no longer contact idler.

o. Remove 2 pins that secure housing to inlet duct flange and remove null adjuster.

p. Remove idler from duct flange and secure to null adjuster by installing clevis pin through idler and clevis.

q. Install bolts, washers, and nutplate on propellant duct. Torque inlet duct bolts to 25-34 in-lb. Use washers previously removed to obtain a 0.010 ±0.005-inch gap between duct flanges.

r. Safetywire bolts.

s. If engine is installed in stage, secure inlet duct to stage with dry-lubed bolts. Torque bolts to requirements in R-3825-1.

3.6.2 INSTALLING ENGINE.

a. Aline oxidizer and fuel inlet ducts (paragraph 3.6.1).

b. Install engine on engine vertical installer. (Refer to R-3825-3.)

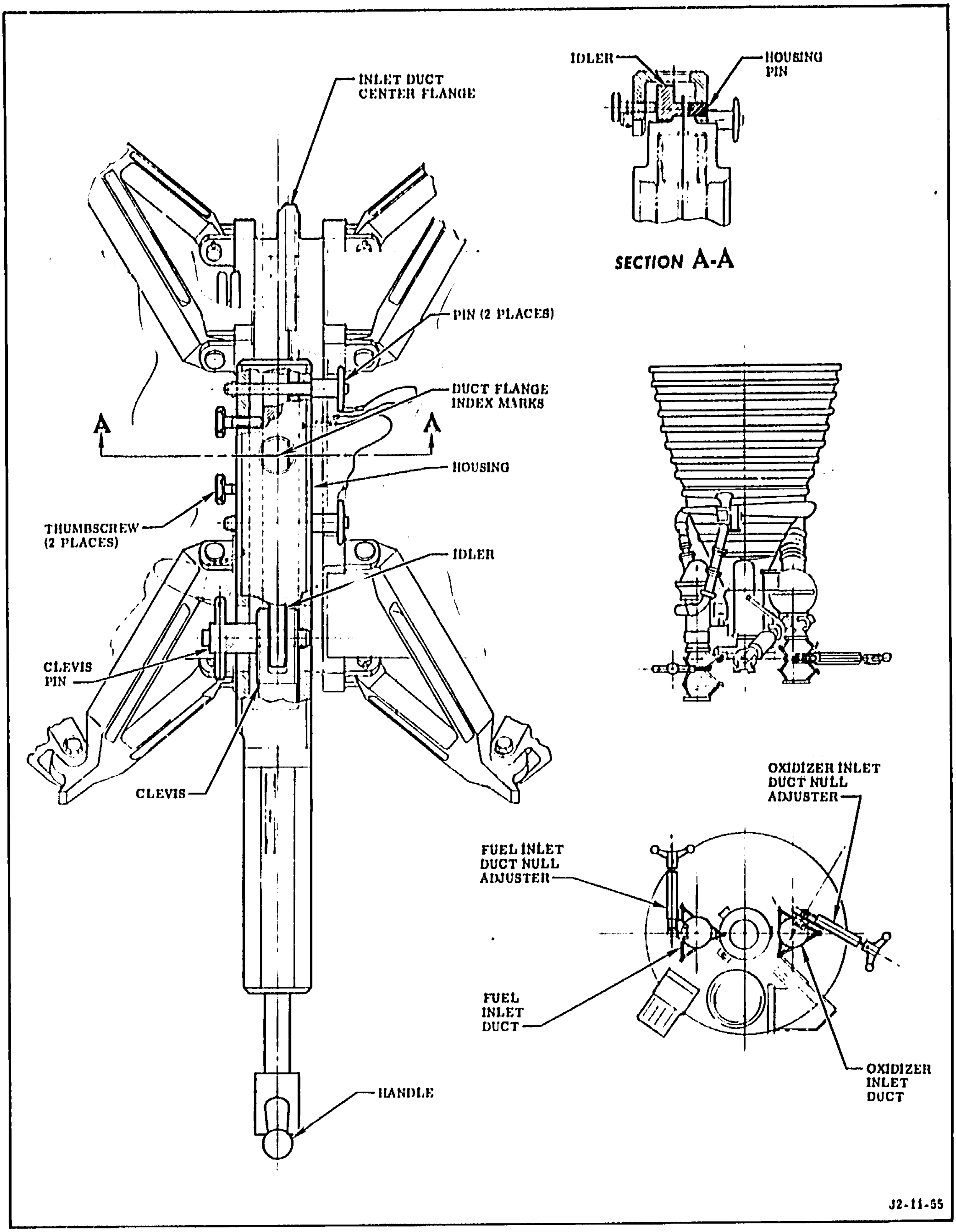


Figure 3-62. Alining Propellant Inlet Ducts

c. Remove oxidizer inlet duct supports and flexible covers from oxidizer inlet duct.

NOTE

The oxidizer duct is normally 22.85 inches long and can be compressed 4 inches with handler 9016785-11. The duct must not be compressed to less than 18.85 inches or extended to more than 26.85 inches.

d. Compress oxidizer inlet duct approximately one inch using installing tool 9026636 from inlet duct support frame installing tool kit 9025150 attached to ends of inlet duct bipods or using oxidizer inlet duct handler 9016785-11.

e. Remove fuel inlet duct supports and flexible covers from fuel inlet duct.

f. Compress fuel inlet duct approximately one inch using installing tool 9026636 from inlet duct support frame installing tool kit 9025150 attached to ends of inlet duct bipods or using fuel inlet duct handler 9016784 as follows:

(1) Retract supports 9022803 using nuts 9022825 (2 places), rotate lock 9024800 out of position, and secure with ball-lock pin.

(2) Place slide arm 9024799 in extreme outward position and secure with ball-lock pin.

(3) On engines not incorporating MD287 change, remove vent port check valve from fuel inlet duct. Carefully place handler on duct.

(4) Make sure notches in top and bottom end plates engage lugs on duct bipod attach fittings.

(5) Move slide arm 9024799 into position, engage lock 9024800, and secure with ball-lock pin.

(6) Extend supports 9022803 using nuts 9022825 (2 places).

NOTE

The fuel duct is normally 22.85 inches long and can be compressed 4 inches with handler 9016784. The duct must not be compressed to less than 18.85 inches or extended to more than 26.85 inches.

(7) Using ratchet wrench on handler, compress duct approximately one inch.

g. Position vertical installer directly below thrust mount to within 1-1/2 inches fore and aft and 1-1/2 inches right and left. Set caster brakes on vertical installer.

h. Remove engine handling adapters from forward end of thrust chamber.

i. When using engine vertical installer incorporating MD4 change to install J-3 engine in stage, use Stage Contractor procedures to raise engine to engine-to-stage mating position; then proceed to step au of this procedure.

CAUTION

Contacting or bumping engine components with the engine bracket can result in extensive damage to the engine.

j. On SII-stage center engines, attach fuel-side engine bracket 9021000-11 to oxidizer dome pad at ASI fuel manifold block. Torque bolts to 150-200 in-lb. Do not contact or bump engine components with engine bracket.

k. On SII-stage outboard engines, install fuel-side bracket 9025858 with dowel pin outboard and engaged in gimbal actuator attach point located approximately 45 degrees counterclockwise (looking aft from forward end of engine) from MOV; then install and secure fuel-side keeper 9022160 (inboard of bracket 9025858) with 2 captive quick-release pins. (See figure 3-63.)

l. On SII-stage engines, attach oxidizer-side engine bracket 9022273 to oxidizer dome pad located 90 degrees clockwise of MOV. Torque mounting bolts to 10-20 in-lb. (See figure 3-63.)

m. On SIVB-stage engines, install fuel side bracket 9022159 with dowel pin outboard and engaged in gimbal actuator attach point located approximately 45 degrees counterclockwise (looking aft from forward end of engine) from MOV; then install and secure fuel side keeper 9022160 (inboard of bracket 9022159) with 2 captive quick-release pins. (See figure 3-64.)

n. On SIVB-stage engines, attach oxidizer-side outboard engine bracket 9021002 to oxidizer dome pad located 90 degrees clockwise of MOV. Torque mounting bolts to 10-20 in-lb.

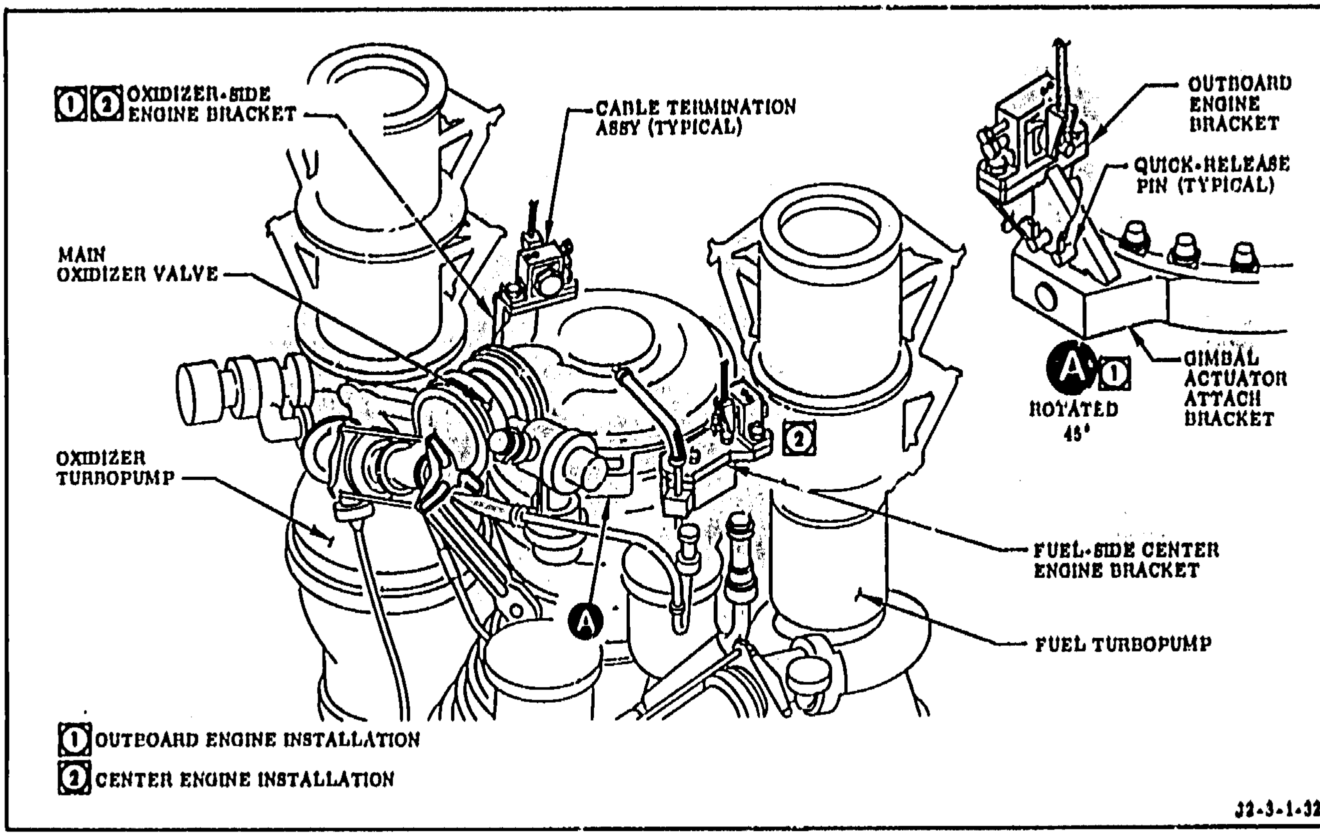


Figure 3-63. Bracket Attach Points (SII-Stage Engines)

o. On SIVB-stage engines, attach oxidizer-side pier 9022158 to bracket 9021002. Torque mounting bolts to 150-200 in-lb.

p. Set cable termination assembly blocks in nominal position, and retract wedge bolt to maintain block in upper position.

NOTE

On vertical installers incorporating MD2 change, one of the cable termination assembly housings is modified to provide clearance for the engine fuel inlet duct.

q. Install cable termination assemblies 9021698 and 9021698-11 on applicable brackets and piers as shown in figures 3-63 and 3-64. Use 2 washers MS20002C10 under head of attaching bolt MS20010-10. Torque bolts to 100-150 in-lb.

NOTE

The control station must be placed in a position that allows the operator to safely observe the equipment and the assisting personnel during operation.

r. Remove electrical control station from installer storage compartment. Make sure all switches are in off position.

s. Connect an external ground cable from engine vertical installer frame to facility ground. Make sure paint does not insulate connections. Refer to R-3825-5 for engine vertical installer ground-cable fabrication requirements.

WARNING

An improperly wired power cable can cause an electrical potential between the vertical installer frame and the ground, resulting in death to personnel if contact is made between the vertical installer and the ground.

t. Make sure electrical power cable is wired so that engine vertical installer frame has same ground potential as facility.

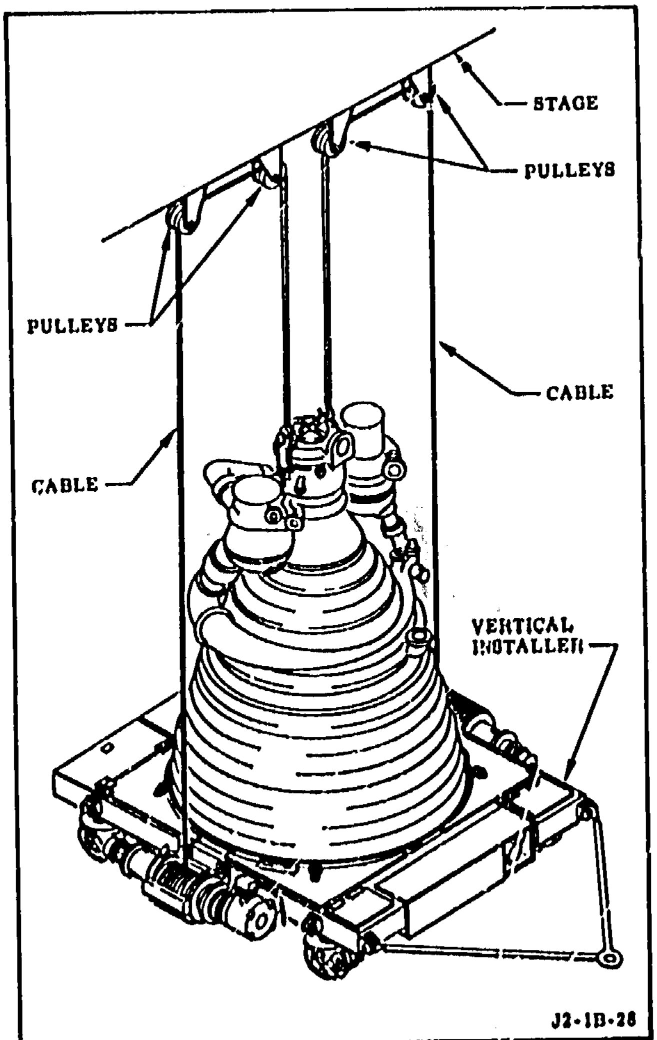


Figure 3-65. Hoist Pulley Connections

ac. Actuate ENGINE UP button in short periods to take up slack in cables.

WARNING

The control station selector switch must be positioned at OFF. Injury to personnel and damage to the engine or equipment can result if the control is accidentally actuated.

ad. Position control station selector switch to OFF.

ae. Make sure of equal tension on cables and that all of cable on hoist drums is in grooves. If tension is unequal, move selector switch to INDIVIDUAL, and actuate applicable button to equalize tension.

NOTE

The ends of the tiedown harness must be used to prevent swaying during lifting. For lifts over 4 feet, a rope must be attached to the free ends of the tiedown harness.

af. Detach tiedown harness from installer.

ag. Swing out fluid interface support.

ah. Make sure of the following before lifting engine:

(1) Attach brackets and terminal block are secure.

(2) Caster brakes are on.

(3) Engine is alined with overhead structure.

(4) Clearance exists between overhead and adjacent structures and engine.

(5) Personnel are clear of hazard area.

(6) Personnel are assigned to guide lines attached to tiedown harness.

(7) Control station operator is in a desirable position to observe gimbal mating and clearance.

NOTE

The hoists operate at slow speed when the remote-control button is depressed halfway and at fast speed when fully depressed.

ai. Position selector switch to DUAL; then actuate DUAL CONTROL ENGINE UP button at slow speed. Raise engine approximately 6 inches; then position selector switch to OFF.

i. Position fuel turbopump support link 407577 between thrust chamber and fuel turbopump.

j. Install pin 405010, washer 405039, and locknut NAS679C6 to secure fuel turbopump support link to turbopump. Torque locknut to 143-157 in-lb.

k. Install bolt RD111-4010-4018 and washers 407588 and 407587 to secure fuel turbopump support link to thrust chamber. Torque bolt to 400 in-lb, back off to zero, and retorque to 40 in-lb. Safetywire bolt.

l. Install strut 502464 with pin 502294. Install screw NAS1101C3H4 in pin and tighten screw. Safetywire screw.

m. Reconnect struts 502290, 502464, and 502466 using pins, nuts, and washers. Torque nuts to 50-70 in-lb. Strut 502466 must be installed with large-diameter end toward fuel pump forward mount, and connected to strut 502290 with cutout facing fuel turbopump stabilizer strut.

n. Remove equipment used to support electrical harness support frame.

3.6.3 REMOVING ENGINE.

a. Prepare vertical installer as outlined in R-3825-3; then position installer directly below thrust chamber exit to within 1.5 inches fore and aft and 1.5 inches right and left. Set caster brakes.

b. If engine vertical installer incorporating MD4 change is used to remove engine, remove thrust chamber exit closure from engine and use Stage Contractor procedure to raise and position installer to support engine; then proceed to step g of this procedure.

c. Connect an external ground cable from engine vertical installer frame to facility ground. Make sure paint does not insulate connections. Refer to R-3825-5 for engine vertical installer ground-cable fabrication requirements.

WARNING

An improperly wired power cable can cause an electrical potential between the vertical installer frame and ground, resulting in death to personnel if contact is made between the vertical installer and ground.

d. Make sure electrical power cable is wired so that engine vertical installer frame has same ground potential as facility.

e. Connect installer to 440-vac, 3-phase, 60 Hz electrical power supply with equipment-ground provisions.

f. Install applicable attach brackets and cable termination assemblies to engine. (Refer to paragraph 3.6.2.)

g. Disconnect fuel and oxidizer inlet ducts.

h. Compress oxidizer inlet duct approximately one inch using installing tool 0026636 from installing tool set 0025150 attached to ends of inlet duct bipods or using oxidizer inlet duct handler 9016785-11.

i. Compress fuel inlet duct approximately one inch using installing tool 0026636 from installing tool set 0025150 attached to ends of inlet duct bipods or using fuel inlet duct handler 9016784 as follows:

(1) Retract supports 0022803 using nuts 0022825 (2 places), rotate lock 0024800 out of position, and secure with ball-lock pin.

(2) Place slide arm 0024700 in extreme outward position and secure with ball-lock pin.

(3) On engines not incorporating MD287 change, remove fuel inlet duct vent port check valve. Carefully place handler on duct.

(4) Make sure notches in top and bottom end plates engage lugs on duct bipod attach fittings.

(5) Move slide arm 0024700 into position, engage lock 0024800, and secure with ball-lock pin.

(6) Extend supports 0022803 using nuts 0022825 (2 places).

(7) Using ratchet wrench on handler, compress duct approximately one inch.

j. If engine vertical installer incorporating MD4 is used to lower engine, make sure of the following:

(1) Fluid lines interface is disconnected. (Refer to paragraph 3.6.2.1.)

(2) Electrical interface is disconnected. (Refer to paragraph 3.6.3.2.)

(3) Gimbal actuators are disconnected. (Refer to paragraph 3.6.3.1.)

k. If engine vertical installer incorporating MD4 is used, make sure vertical installer is raised and in firm contact with thrust chamber exit; then remove gimbal to stage attach bolts, and secure engine to installer with engine tiedown harness. Use Stage Contractor procedures to lower engine and installer; then proceed to step w of this procedure.

l. Before lowering engine, make sure of the following:

(1) Fluid line interface is disconnected. (Refer to paragraph 3.6.2.1.)

(2) Electrical interface is disconnected. (Refer to paragraph 3.6.3.2.)

(3) Gimbal actuators are disconnected. (Refer to paragraph 3.6.3.1.)

(4) Attach brackets and termination assemblies are secured.

(5) Castor brakes are on.

(6) Engine is in alinement with installer.

(7) Clearance exists between overhead and adjacent structures and engine.

(8) Personnel are clear of hazard area.

(9) Personnel are assigned to guide lines attached to tiedown harness.

(10) Control station operator is in a desirable position to observe gimbal and clearance problems.

m. Remove engine exit closure from engine.

n. Remove gimbal bolts.

o. Lower engine to within 6 inches of installer support ring.

p. Make sure of vertical alinement between installer and engine. Correct any deviation by moving selector switch to INDIVIDUAL and actuating applicable button.

CAUTION

Damage to oxidizer pump seal drain line may occur if it is allowed to contact installer when lowering engine.

q. Slowly lower engine onto installer. Thrust chamber must contact support ring as uniformly as possible and be centered on rubber pad.

r. Secure ends of tiedown harness to installer tiedown rings.

s. Slack off cables and remove cable termination plugs from cable termination assemblies.

t. Remove cables from overhead pulleys, wearing heavy gloves, and reel in.

u. Disconnect electrical power from installer, and store control station in storage compartment.

v. Remove attach brackets and cable termination assemblies from engine and store in installer components.

w. Remove fuel and oxidizer inlet duct installing tools or handlers, and install duct supports.

x. On engines not incorporating MD287 change, if fuel inlet duct vent port check valve was removed, install seal on vent port check valve and reinstall valve. Torque valve to 175-200 in-lb, and safetywire.

y. Make sure the following covers and closures are installed on engine:

(1) Oxidizer and fuel inlet duct covers and closures.

(2) Fluid line interface covers and closures.

(3) Electrical interface covers and closures.

(4) Thrust chamber cover and exit closures.

(5) Heat exchanger cover.

(6) Oxidizer turbine bypass duct covers.

(7) Turbine crossover duct covers.

(8) Oxidizer and fuel inlet duct bipod covers.

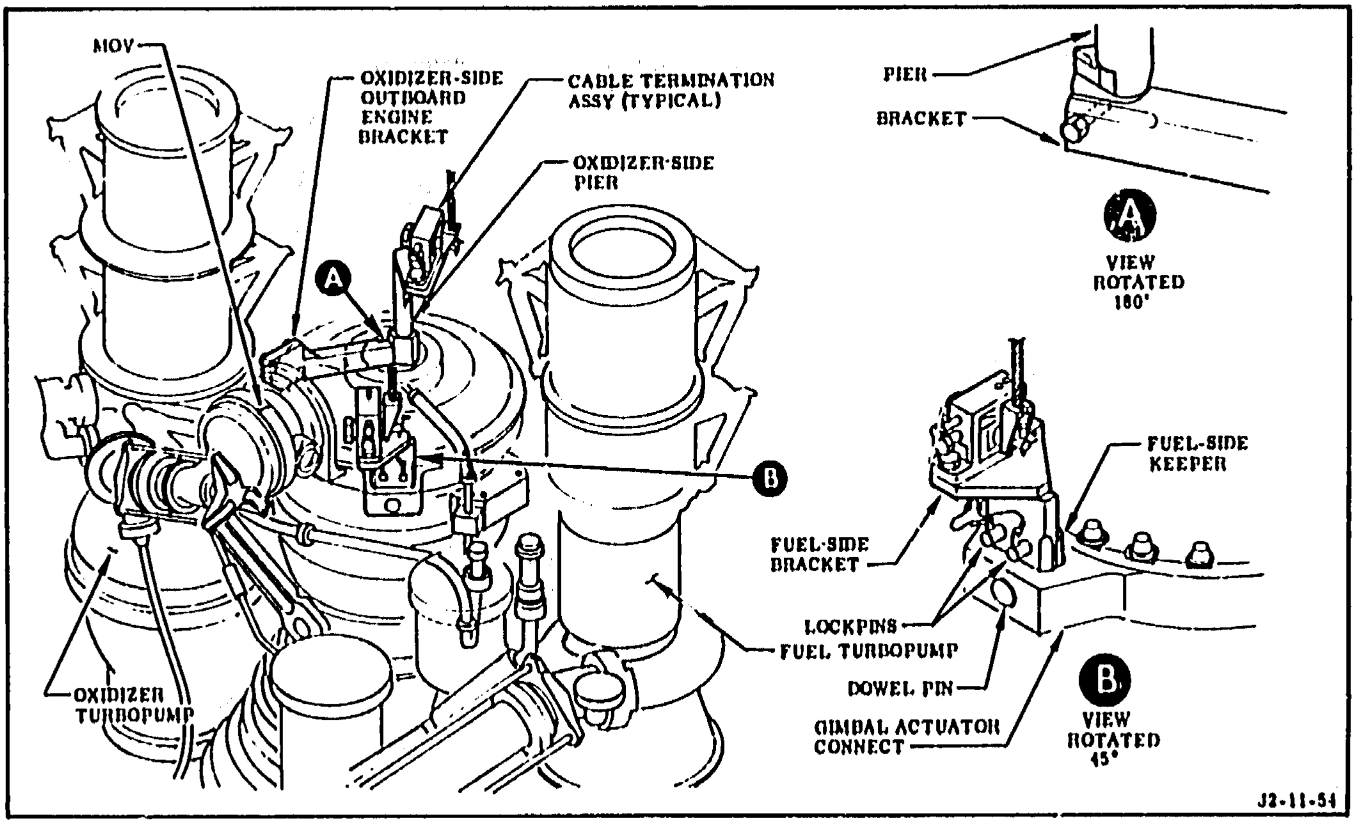


Figure 3-64. Bracket Attach Points (SIVB-Stage Engines)

u. Connect installer to 440-vac, 3-phase, 60 Hz electrical power supply with equipment-grounding provisions.

v. Make sure MAIN POWER ON lamp on remote control station is on.

w. Inspect the following before starting operation:

(1) Hoist for electrical and mechanical action.

(2) Cable for visible defects.

(3) Each cable wrap for position in drum grooves.

(4) Stage or test stand for proper installation of pulleys. (See figure 3-65.)

x. Position control station selector switch to DUAL.

y. Actuate DUAL CONTROL ENGINE DOWN button and, wearing heavy gloves, reel out both cables.

z. Pass cables through pulleys and down to cable termination assemblies installed in step q.

CAUTION

The oxidizer pump seal drain line must be watched during rotation of the engine on the installer, to prevent damage to the drain line.

NOTE

It may be necessary to loosen or release the engine tiedown harness.

aa. Release support ring brake, and rotate engine to aline cable termination assemblies with cables.

ab. Connect cables to cable termination assemblies by removing lockpin, inserting cable termination plug in retainer, and reinstalling lockpin.

CAUTION

For lifts of 3 feet or less, hoist must be operated on slow speed. For lifts over 3 feet, hoist may be operated on fast speed until a distance of 3 feet from gimbal mating is reached. At this point, speed must be reduced, since damage to the engine can occur.

- Pneumatic interface fluid lines and electrical cables must be clear of all protruding objects during the lifting operation, since damage to the engine can occur.

aj. Make sure that engine is hanging vertically. Adjust, if required, by moving selector switch to INDIVIDUAL and actuating applicable button. Inspect for slippage in hoist brakes.

ak. Position selector switch to DUAL; then actuate DUAL CONTROL ENGINE UP button, and raise engine to within approximately 6 inches of gimbal mating position.

al. Remove protective closures from oxidizer and fuel inlet ducts and their mating ports.

am. If installing an SII center engine, position oxidizer and fuel inlet duct seals on oxidizer and fuel turbopump inlet flanges.

an. Position selector switch to DUAL; then actuate DUAL CONTROL ENGINE UP button. Raise engine to within 2 inches of gimbal mating.

ao. Position selector switch to OFF.

CAUTION

To prevent damage to flanges and sealing surfaces, the fuel and oxidizer inlet ducts must be compressed to clear the mating connections when the gimbal is mated.

ap. Inspect gimbal for alinement and interface connections for clearance. If gimbal is not alined, adjust longitudinal and transverse adjusting screws on cable termination blocks, as required. (See figure 3-66.)

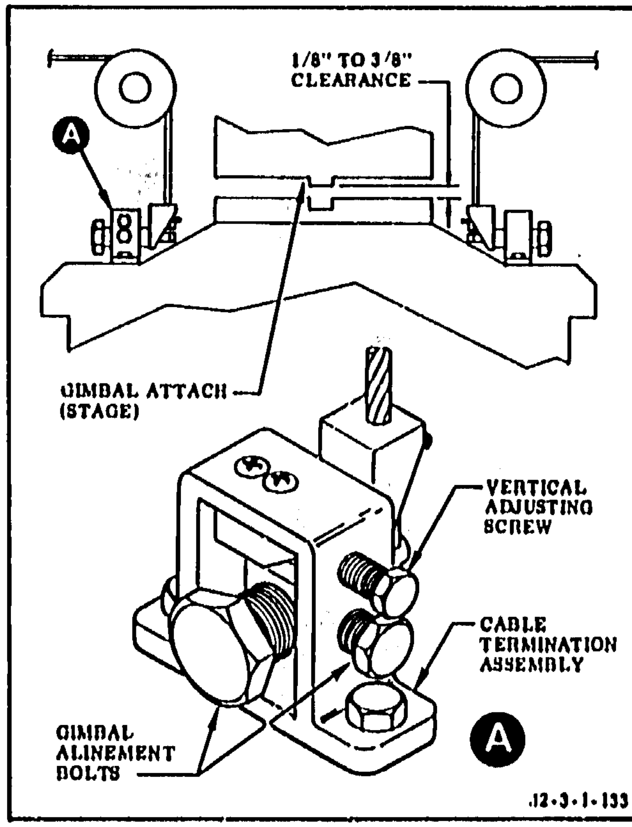


Figure 3-66. Gimbal-to-Stage Installation Alinement

aq. Position selector switch to DUAL; then actuate DUAL CONTROL ENGINE UP button at slow speed until engine gimbal is between 1/8 and 3/8 inch from gimbal mating.

ar. Position selector switch to OFF.

as. Verify gimbal alinement; adjust if necessary. (See figure 3-66.)

at. Raise engine using vertical adjusting screws on cable termination blocks until gimbal has mated and engaged approximately 1/8 inch minimum.

au. Insert gimbal bolts and torque.

av. If SII center engine is being installed, proceed to step ay; if an SII outboard engine or SIVB engine is being installed, proceed to step aw.

aw. Install interface seal on fuel and oxidizer inlet ducts.

ax. Aline inlet ducts and seals with interface mating connections, decompress ducts, and remove handlers. Install washers and dry-lube bolts, and torque to requirements in R-3825-1. Safetywire bolts, and proceed to step az.

ay. Aline oxidizer and fuel inlet ducts and seals to oxidizer and fuel turbopump inlet flanges. Install washers and dry-lube bolts, and torque to requirements in R-3825-1. Safetywire bolts, and proceed to step ba.

az. On engines not incorporating MD287 change, if fuel inlet duct vent port check valve was removed, install seal on vent port check valve and reinstall valve. Torque valve to 175-200 in-lb, and safetywire.

ba. If engine vertical installer incorporating MD4 change was used to raise engine, use Stage Contractor procedures to lower installer to transporting position; then proceed to step bg.

bb. Position selector switch to DUAL. Slack off cables by actuating DUAL CONTROL ENGINE DOWN button. Remove cable termination plugs from cable termination assemblies.

NOTE

DUAL or INDIVIDUAL controls may be used to reel in cables.

bc. Remove cables from overhead pulleys and, wearing heavy gloves, reel in cables.

bd. Remove termination assemblies, attach brackets, and tiedown harness from engine, and store in appropriate compartments.

be. Make sure MAIN POWER LIGHT is off.

bf. Disconnect electrical power from vertical installer, and store control station in storage compartment.

bg. Remove installer from installation area. Using spanner wrench 0021031, rotate casters to trail position.

bh. Perform requirements of paragraphs 3.6.3, 3.6.5, and 3.6.7.

bi. Make sure the following covers and closures are installed on engine:

(1) Thrust chamber cover and exit closure.

(2) Heat exchanger covers.

(3) Oxidizer and fuel inlet duct covers.

(4) Oxidizer turbine bypass duct covers.

(5) Turbine crossover duct covers.

(6) Oxidizer and fuel inlet duct bipod covers.

(7) Helium high-pressure relief valve cover (engines incorporating MD272 change).

(8) Fuel bleed line covers.

(9) Oxidizer turbine seal cavity drain line closure.

(10) Fuel turbine seal cavity drain line closure.

(11) Oxidizer pump primary seal drain line closure.

(12) Oxidizer pump intermediate seal purge check valve closure.

(13) Purge control valve vent line closure (on engines not incorporating MD166 change and on engines incorporating MD301, MD302, MD322, or MD323 change).

3.6.2.1 Removing Fluid Lines Interface Support. The fluid lines interface support is attached to the customer-connect lines support and is only removed when the engine is attached to a stage. The interface support has two positions for in and out movement and three positions for up and down movement. Lockpins are provided at both positions to secure the interface support in the desired position. A strap is attached to the arm of the interface support to hold the fluid lines in position. (See figure 3-67.)

a. Pull lockpin and rotate support arm of fluid line interface support 9020628 to aline fluid lines with customer connects.

b. Remove protective covers from customer connects.

c. Remove clamps and support lines, as necessary, while connecting to stage.

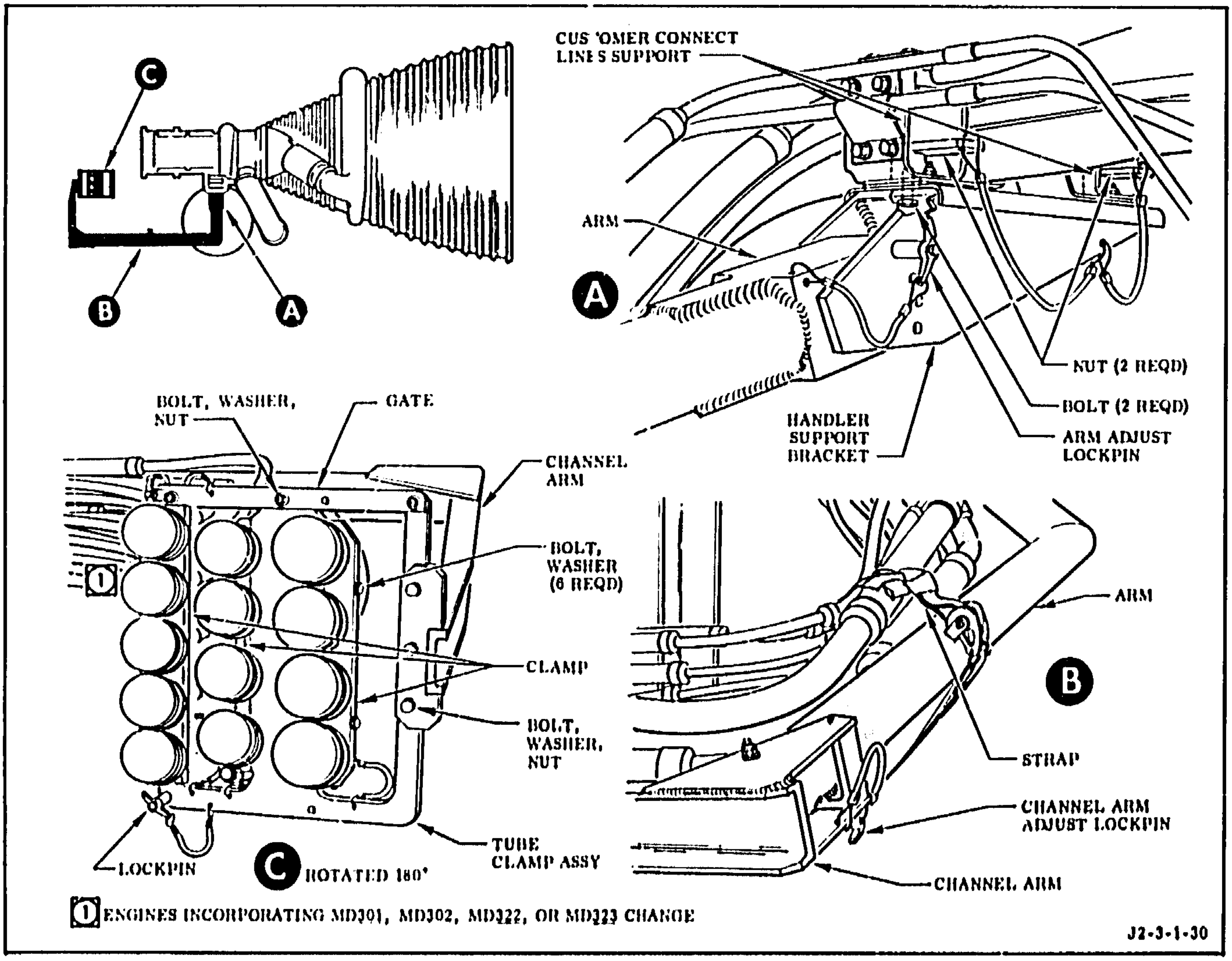


Figure 3-67. Fluid Lines Interface Support

d. Connect LOX BLEED LINE customer connect.

e. Connect FUEL BLEED LINE customer connect.

f. Connect START TANK INITIAL FILL customer connect.

g. Connect HELIUM TANK FILL customer connect.

h. Connect stage pneumatic control pressure line to START TANK VENT VALVE CONTROL customer connect.

i. Connect HYDROGEN TANK PRESSURIZATION customer connect.

j. Connect OXIDIZER TANK PRESSURIZATION customer connect.

k. On engines incorporating MD105 change, connect HEAT EXCHANGER HELIUM INLET customer connect (SIVB stage only).

l. Connect FUEL PUMP DRAIN customer connect.

m. Connect START TANK VENT & RELIEF VALVE DRAIN customer connect.

n. Connect THRUST CHAMBER JACKET PURGE customer connect.

o. Connect PURGE MANIFOLD SYSTEM customer connect.

p. Connect CALIPS CHECKOUT LINE customer connect.

q. On engines incorporating MD301, MD302, MD322, or MD323 change, connect OXIDIZER PUMP PRIMARY SEAL DRAIN customer connect.

r. Remove remaining section of fluid lines interface support 9020628; reassemble and store.

3.6.2.2 Connecting Interface Electrical Cables.

NOTE

When connecting interface electrical cables to the SIVB stage, it is not necessary to disassemble the electrical cable clamping block. The clamping block can be removed from electrical interface support assembly 9024460 and connected to the stage intact.

a. Remove bolts that secure one section of electrical cable clamp block mounted on electrical interface support assembly 9024460 to free first row of cables for connection to test stand or stage electrical connectors.

b. Disconnect engine electrical and instrumentation cables, one at a time, from cable termination panel support on support assembly 9024460, and connect each cable to appropriate connector on test stand or stage electrical interface panel.

c. Disconnect remaining sections of clamp block from support assembly 9024460, and connect balance of cables to appropriate test stand or stage connectors.

NOTE

All electrical connections must be verified to make sure all systems operate properly.

d. (Deleted)

e. Position and hold cables in their proper positions; reassemble cable clamp block on cables, and attach block to test stand or stage mounting brackets. Torque bolts to 99-121 in-lb.

f. Remove electrical interface support assembly 9024460 from engine interface cable support frame, and store.

3.6.2.3 Connecting Gimbal Actuators.

a. Place No. 1 actuator assembly in position, and install actuator pin.

CAUTION

Failure to support electrical harness support frame can result in damage to pins 502295 and transducer PF6.

b. Remove 3 locknuts and washers from pins that secure struts 502290, 502464, 502466 to electrical harness support frame; then remove locknut and washer from pin that secures strut 502466 to strut 502290.

c. Support weight of electrical harness support frame to prevent binding of pins, and remove 4 pins 502295 (nuts and washers removed from these pins in step b). Continue to support electrical harness support frame.

d. Remove screw NAS1101C3H4 from pin 502294 that retains strut 502464. Remove pin and strut.

e. Remove bolt RD111-4010-4018 and washers 407588 and 407587 that secure fuel turbopump support link 407577.

f. Remove locknut and washer from pin 405010 that secures support link 407577 to turbopump.

g. Pivot strut 502290 to one side and remove pin 405010 and support link 407477. If strut 502290 cannot be pivoted out of the way, remove locknut, washer, and pin that secures strut 502290 to thrust chamber; then remove strut, pin, and support link.

h. Place No. 2 actuator assembly in position, and install actuator pin.

(9) Helium high-pressure relief valve cover (engines incorporating MD272 change).

(10) Fuel bleed line covers.

(11) Oxidizer turbine seal cavity drain line closure.

(12) Fuel turbine seal cavity drain line closure.

(13) Oxidizer pump primary seal drain line closure.

(14) Oxidizer pump intermediate seal purge check valve closure.

(15) Purge control valve vent line closure (on engines not incorporating MD166 change and on engines incorporating MD301, MD302, MD322, or MD323 change).

z. Pull vertical installer caster lockpins by hand using spanner wrench 9021031 to turn casters. Position and lock rear casters in trail position; unlock front casters so they can turn.

aa. Transfer engine and installer from installation area, and lock caster brakes.

ab. If engine is to be transferred to engine handler, perform procedures outlined in R-3825-3. If engine is to be placed in vertical storage, refer to R-3825-3.

3.6.3.1 Disconnecting Gimbal Actuators.

a. Disconnect No. 1 gimbal actuator.

b. Disconnect No. 2 gimbal actuator as follows:

CAUTION

Failure to support electrical harness support frame can result in damage to pins 502295 and transducer PF6.

(1) Remove 3 locknuts and washers from pins that secure struts 502290, 502464, and 502466 to electrical harness support frame; then remove locknut and washer from pin that secures strut 502466 to strut 502290.

(2) Support weight of electrical harness support frame to prevent binding of pins, and remove 4 pins 502295 (nuts and washers removed from these pins in substep 1). Continue to support electrical harness support frame.

(3) Remove screw NAS1101C3H4 from pin 502294 that holds strut 502464. Remove pin and strut.

(4) Remove bolt RD111-4010-4018 and washers 407588 and 407587 that secure fuel turbopump support link 407577.

(5) Remove locknut washer from pin 405010 that secures support link 407577 to turbopump.

(6) Pivot strut 502290 to one side and remove pin 405010 and support link 407577. If strut 502290 cannot be pivoted out of the way, remove locknut, washer, and pin that secures strut 502290 to thrust chamber; then remove strut, pin, and support link.

(7) Disconnect No. 2 gimbal actuator.

(8) Position fuel turbopump support link 407577 between thrust chamber and fuel turbopump.

(9) Install pin 405010, washer 405039, and locknut NAS679C6 to secure fuel turbopump support link to turbopump. Torque locknut to 143-157 in-lb.

(10) Install bolt RD111-4010-4018 and washers 407588 and 407587 to secure fuel turbopump support link to thrust chamber. Torque bolt to 400 in-lb, back off to zero, and retorque to 40 in-lb. Safetywire bolt.

(11) Install strut 502464 with pin 502294. Install screw NAS1101C3H4 in pin; tighten and safetywire screw.

(12) Reconnect struts 502290, 502464, and 502466 using pins, nuts, and washers. Torque nuts to 50-70 in-lb.

(13) Remove equipment used to support electrical harness support frame.

3.6.3.2 Disconnecting Interface Electrical Cables.

a. Clamp electrical interface support assembly 9024460 to engine interface cable support frame. Torque bolts that secure clamp to 50-70 in-lb.

NOTE

When disconnecting interface electrical cables from the SIVB stage, it is not necessary to disassemble the cable clamping block. All cables can be disconnected, and the cable clamping block can be removed from the stage intact and clamped to electrical interface support 9024460.

b. Remove bolts that secure one section of electrical cable clamp block (at vehicle cone mounting point) to free first row of cables for connection to interface support assembly 9024460.

c. Disconnect engine electrical and instrumentation cables, one at a time, from vehicle connectors, and connect each cable to appropriate connector on outer panel of support assembly 9024460. (Refer to R-3825-3 for procedure for disconnecting electrical connectors.)

d. Remove bolts, disconnect remaining sections of clamp block from vehicle cone mounting point, and connect balance of cables to appropriate connector on outer panel of support assembly 9024460.

e. Position and hold cables in their proper positions. Install bolts and washers, and reassemble cable clamp block in cables. Torque bolts to 30-40 in-lb.

f. Install bolts that secure cable clamp block to support assembly.

3.6.3.3 Installing Fluid Lines Interface Support. Install fluid lines interface support as follows (figure 3-67), using support 9020628-31. (On engines incorporating MD190 change, support 9020628-41 must be used. If support 9020628-41 is not available, support 9020628-21 or -31 may be used.)

a. Remove tube clamp assembly from channel arm of support.

b. Lift support in place on engine, and connect handler support bracket to engine customer-connect lines support with 2 nuts and bolts. Hold nuts and torque bolts to 61-75 in-lb.

c. Position support arms adjacent to fluid interface lines, disassemble tube clamp assembly, and attach tube clamp assembly to channel arm. Torque 1/4-inch nuts to 50-70 in-lb. 1/4-inch bolts to 63-77 in-lb and 3/8-inch nuts to 160-190 in-lb.

d. If an engine not incorporating MD190 change is installed and support 9020628-21 or -31 is not being used, disconnect fluid lines from stage or test stand. Position and secure lines to tube support clamp. Torque the 6 captive bolts in the 3 tube clamps to 55-67 in-lb.

e. If an engine not incorporating MD190 change is installed and support 9020628-21 or -31 is being used, disconnect fluid lines from stage or test stand. Position and secure lines to tube support clamp. Torque the 2 captive bolts in tube clamp that secures thrust chamber jacket purge line to 5 in-lb above starting torque; torque remaining 4 bolts in tube clamps to 55-67 in-lb.

f. Connect strap around lines, swing out support, and install protective covers on lines. Install arm lockpins.

3.6.4 INSTALLING ENGINE RESTRAINER. (See figure 3-68.)

CAUTION

The lugs on the engine fuel manifold cannot support the weight of the engine restrainer frame. The restrainer must be supported by an overhead crane, pulleys, or manpower until the two vertical outboard struts are installed. Damage to the engine can result if the frame is not supported.

- Struts must not be forced into attach points, since damage to equipment can result.

a. Hoist engine restrainer into position adjacent to thrust chamber fuel manifold. Do not

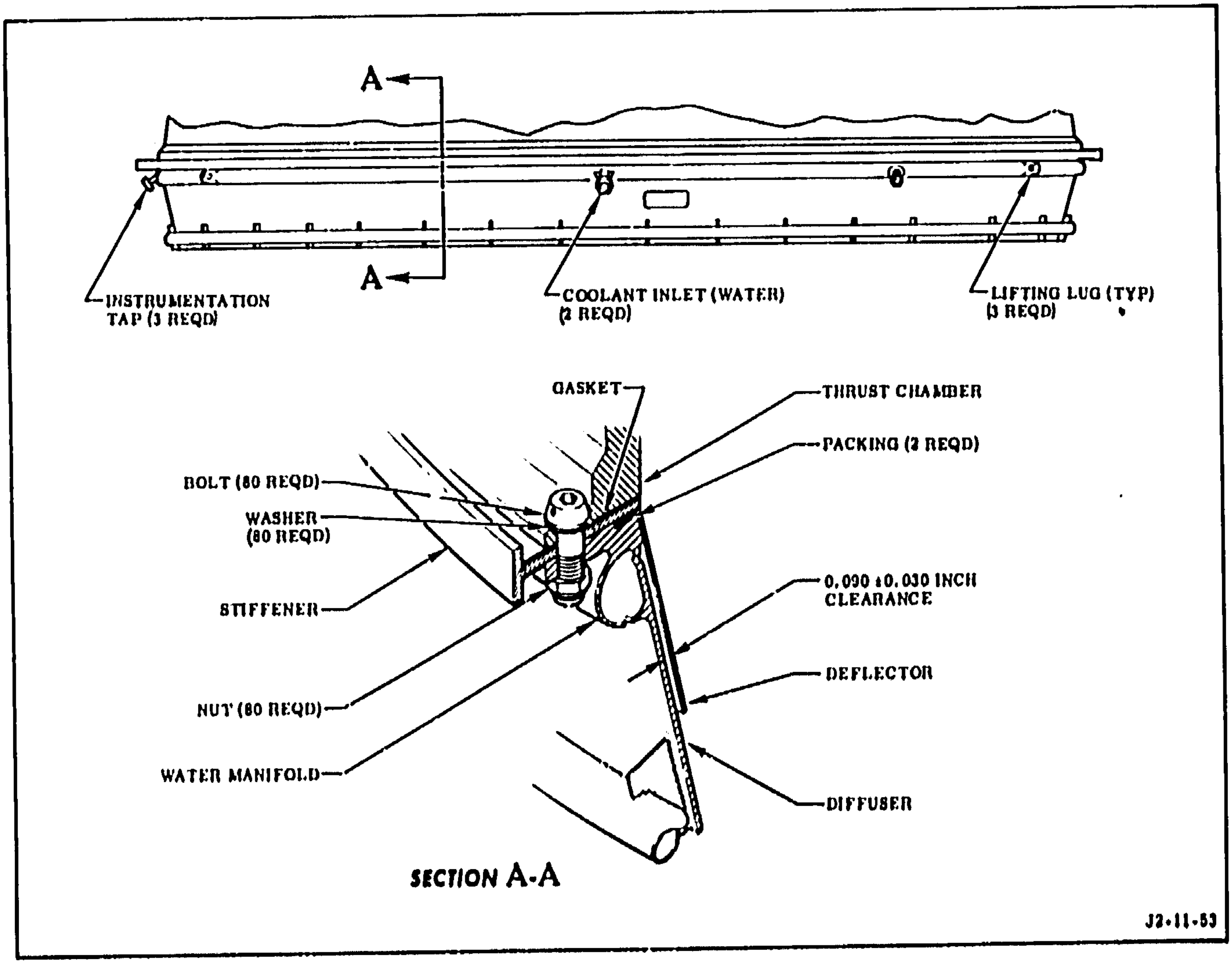


Figure 3-69. Film-Cooled Diffuser

b. Disconnect outriggers from restrainer frame attach points.

CAUTION

The lugs on the engine fuel manifold cannot support the weight of the engine restrainer. The restrainer must be supported by an overhead crane, pulleys, or manpower. Damage to the engine can result if the restrainer is not supported.

c. Install a support on engine restrainer frame and attach to hoist.

d. Remove vertical center strut from thrust chamber and frame of engine restrainer.

e. Remove vertical outboard struts from thrust chamber and frame of engine restrainer.

f. Remove short struts 9024630 and 9024631 from fuel manifold and engine restrainer frame.

g. Remove bolts and nuts that secure engine restrainer frame to fuel manifold. Carefully remove restrainer from engine. Do not allow restrainer to bump against engine lines or components.

3.6.6 INSTALLING FILM-COOLED DIFFUSER. (See figures 3-69 to 3-70.)

a. Place diffuser in a horizontal position with packing groove up.

allow restrainer to bump against engine lines or components. Engine restrainer is attached to fuel turbopump side of engine.

CAUTION

Attaching struts must be removed or swung away from thrust chamber and secured while hoisting engine restrainer into position. Protruding struts can damage the engine during the hoisting operation.

b. Make sure gimbal actuators have been installed and adjusted.

c. Install gimbal actuator mechanical locks.

d. Manually apply force in minus Z-axis direction (R-3825-1) at thrust chamber exit to firmly seat gimbal mounting surfaces. Force applied must not exceed 300 pounds. Apply force until steps e through n are performed.

e. Attach engine restrainer to engine fuel manifold lugs as shown in figure 3-68. Secure to engine fuel manifold with slides, bolts, washers, and nuts. Center slide and retain with centering pin 9024537.

f. Adjust and attach struts 9024530 and 9024531 to lugs of fuel manifold. Secure struts to fuel manifold with bolts and nuts. Torque nuts to 30-100 in-lb.

g. Adjust and attach the 2 vertical outboard struts 9024535 to engine restrainer frame and thrust chamber throat ring attach brackets. Adjust strut length by loosening locknut of strut. Adjust clevis and torque locknut to 190-210 in-lb when desired strut length is obtained. (Outboard struts must be adjusted to obtain minimum bending at short strut and at restrainer frame connections to fuel manifold. Restrainer lateral frame centerline (shown in profile view in figure 3-68) must be within 90 ±3 degrees of thrust chamber centerline.)

CAUTION

Lockpins must be firmly in place. If the lockpins accidentally fall out, damage to equipment can result.

h. Secure struts to bracket with lockpins.

CAUTION

The rod end must be installed so that the bolthole will be at a 90-degree angle to the centerline of the thrust chamber. Damage can result if the strut does not have proper movement.

i. Install rod end for vertical center strut into lug provided on thrust chamber. Rod end must have a minimum thread engagement of 0.66 inch. Lug is located aft of throat area adjacent to turbine seal drain lines.

j. Torque locknut on rod end at thrust chamber attach point to 48-52 in-lb.

k. Adjust and attach vertical center strut to rod end and restrainer frame with bolt, washers, nut, and lockpin. Torque locknut at restrainer end of rod to 190-210 in-lb.

CAUTION

The restrainer frame must not bend any of the lugs on the fuel manifold, since damage to the engine can result.

l. Remove engine restrainer support. If bending of fuel manifold lugs occurs, reinstall restrainer supports and readjust rod end bearings on vertical outboard and vertical center struts.

m. Remove slide centering pins 9024537.

n. Attach 2 outriggers to engine restrainer frame. With a surveyor's transit, aline outriggers with respect to plane of engine restrainer frame, vertically and horizontally, to values shown in figure 3-68. Adjust outriggers by moving outrigger attach point on test stand and by lengthening or shortening outrigger arms.

3.6.5 REMOVING ENGINE RESTRAINER. (See figure 3-68.)

a. Inspect engine restrainer and all attachment points for broken or deformed parts, loose connections, and cracked or abnormal weld joints. Refer to R-3825-6 for repair procedures. Between 20 to 30 operations (engine starts), inspect engine restrainer as outlined in R-3825-5.

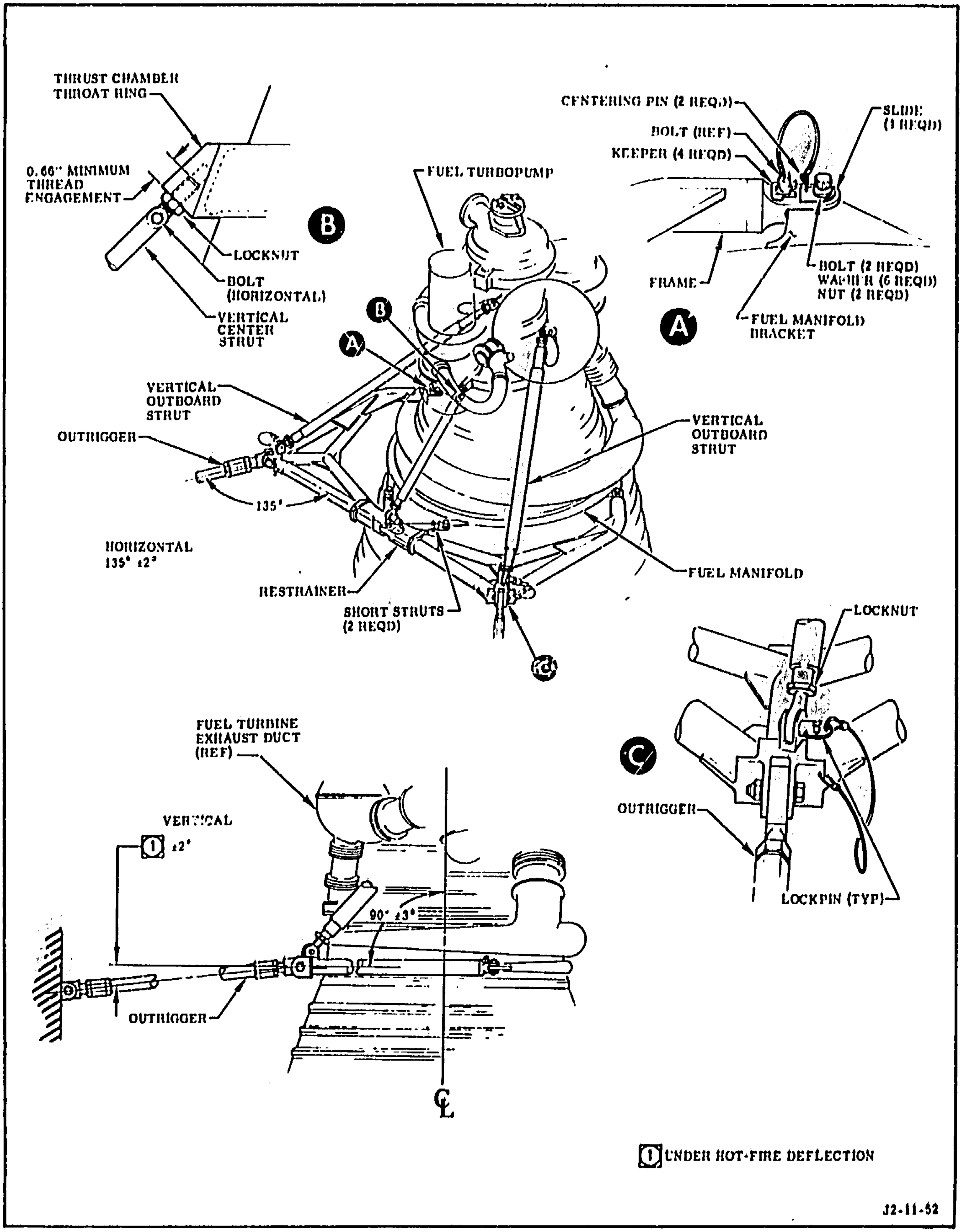
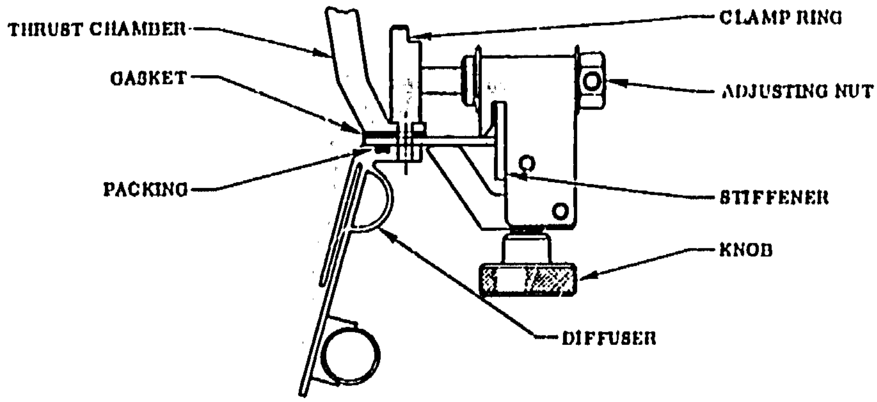
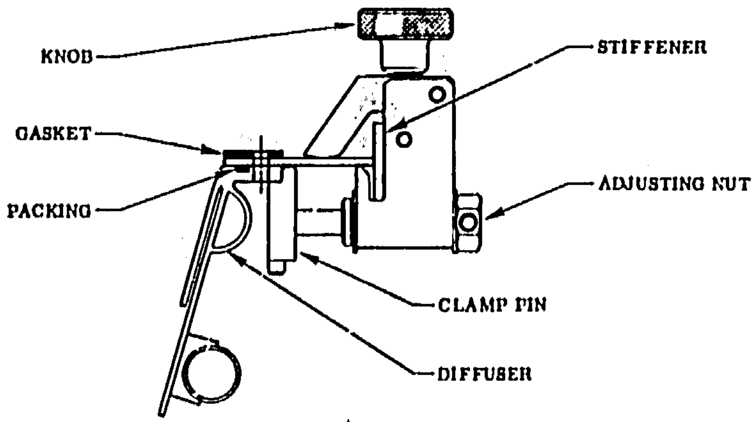


Figure 3-68. Installing Engine Restrainer



DIFFUSER INSTALLING TOOL POSITIONED FOR ADJUSTING THE ENGINE EXIT FLANGE TO THE STIFFENER



DIFFUSER INSTALLING TOOL POSITIONED FOR ADJUSTING THE DIFFUSER TO THE STIFFENER

J2-1B-29

Figure 3-70. Installing Film-Cooled Diffuser

b. Install 1/8-inch J. M. 397 Thermocore packing (Johns-Manville Products) in diffuser packing groove. Cut packing to proper length so that ends meet without leaving a gap. (Two lengths of packing approximately 250 inches long are required to fill diffuser packing groove.)

c. Place stiffener on top of diffuser flange and aline holes radially.

d. Remove lockwire from 8 thrust chamber drain screws to aid installation of mounting bolts.

e. Attach 3 installing tools 9026626 from diffuser installing tool set 9025144, with knobs up and clamp pins down, to T-flange of stiffener. Position installing tools approximately 120 degrees apart around periphery of stiffener. Tighten knobs handtight.

f. Adjust installing tool clamp by turning adjusting nut until notch in clamp pin engages flange of stiffener. Continue to turn adjusting nut until holes in stiffener nearest installing tool aline with holes in diffuser.

g. Install gasket 9022255 on stiffener, aline holes, then trim gasket ends until ends meet without leaving a gap. (Too keep gasket from slipping during installation, tie gasket to gasket mounting surface of stiffener.)

h. Raise diffuser into position below engine, rotate until water inlets aline with facility water supply; then aline holes in diffuser and exit flange of thrust chamber.

i. Locate 3 alined boltholes approximately 120 degrees apart and install 3 (each) bolts, washers, and nuts. Do not torque nuts; leave bolts loose with ends protruding just beyond nuts.

j. Attach 3 more diffuser installing tools next to those installed in step e, with clamp pin inserted into holes alined in step f. Install tools with knobs down and tighten knobs hand-tight.

CAUTION

Drift pins must not be used to aline holes, since damage to water manifold or diffuser can result.

k. Turn installing tool adjusting nut until holes in thrust chamber exit flange and diffuser are alined.

l. Relocate and adjust installing tools until all bolts, washers, and nuts are installed. Install washers with washer radius next to bolthead radius. If sufficient thread is available, install washer LD153-0010-0011 under each nut.

m. Torque all nuts to 38-40 in-lb. It is not necessary to safetywire bolts.

n. Install and safetywire the 8 thrust chamber drain screws.

CAUTION

The clearance in step o must be maintained to prevent damage to the diffuser during the engine ground test.

o. Make sure a clearance of 0.09 ±0.03 inch exists between deflector and diffuser.

p. Connect 2 water coolant lines to water manifold inlets. Using a tee, connect a nitrogen purge line to one water line. The diffuser operating flowrate must be between 20 (minimum) and 24 (maximum) pounds of water per second. Use calibration curve supplied with diffuser to determine required pressure. Water must flow through all orifices and impinge upon diffuser skirt surfaces in such a manner as to provide good distribution and act as a film coolant.

NOTE

Manifold pressure must be measured at the instrumentation boss located approximately midway between water inlets.

3.6.7 <u>REMOVING FILM-COOLED DIFFUSER.</u>
(See figures 3-69 and 3-70.)

a. Inspect film-cooled diffuser for eroded or burned-through areas and restricted or plugged coolant holes. Discoloration from heat is acceptable. Inspect internal coolant holes with a probe or by testing the diffuser.

NOTE

Internal coolant holes can be checked by observing that a continuous uniform film of water is applied to the inner surfaces of the diffuser during a diffuser water flow test.

b. Disconnect facility or stage connect lines. Cap lines.

c. Remove lockwire from 8 thrust chamber drain screws.

CAUTION

The diffuser assembly must be properly supported before removing the attaching bolts.

d. Remove bolts, washers, and nuts that secure diffuser, packings, stiffener, and gasket to thrust chamber. Remove diffuser assembly.

NOTE

The gasket may be retained for reinstallation if not damaged.

e. Remove packings from packing groove.

NOTE

The packings may be retained for reinstallation if there is no indication of burning or graphite removal.

f. Safetywire 8 thrust chamber drain screws.

3.6.8 REPOSITIONING OXIDIZER AND FUEL INLET DUCT BIPOD PINS.

a. Inspect each retaining pin for proper installation. Each pin must extend through and protrude at least 1/16 inch on each side of bipod pivot pin. If protrusion is within limits, disregard remainder of procedure.

b. If protrusion is not within limits, position retaining pin with drive pin and light hammer until retaining pin protrudes approximately equal distances on each side of pivot pin. Minimum protrusion is 1/16 inch.

c. Inspect pin for damage. If damage is not detected, disregard remainder of procedure. (Slight burring of pin resulting from interference fit is allowable. If burring is detected, notify Engine Contractor representative for disposition.)

d. If damage is detected, note number and position of pivot pin shims. (Shims establish required alinement of bipod to duct and must be reinstalled in position noted, if pivot pin is removed to replace retaining pin.) Hold pivot pin in place when performing steps e and f, to prevent pin from becoming disengaged from bracket.

e. Using drive pin and light hammer, remove defective retaining pin.

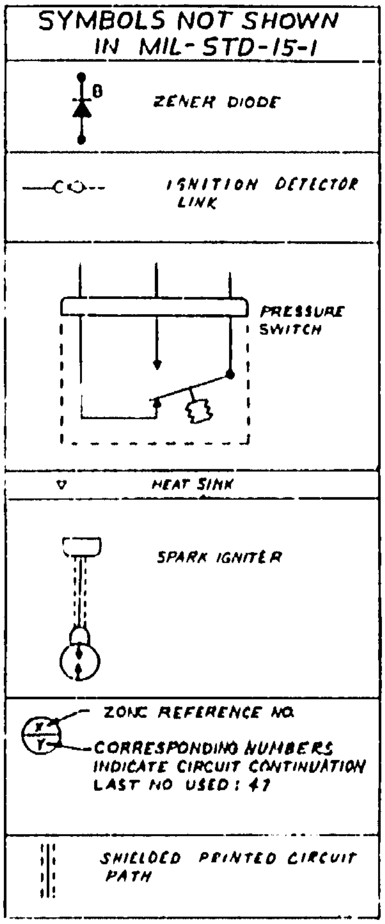
f. Install new retaining pin by inserting pin in pivot hole as far as possible by hand, then using drive pin and light hammer position retaining pin until it is approximately evenly spaced in pivot pin. Minimum protrusion of pin is 1/16 inch.

3.6.9 REPLACING IGNITION DETECTOR PROBE. Refer to R-3825-3 for ignition detector probe removal and installation procedures.

3.6.10 REPLACING GAS GENERATOR OVERTEMPERATURE TRANSDUCER. Refer to R-3825-3 for GG overtemperature transducer removal and installation procedures.

3.7 ENGINE SCHEMATICS.

3.7.1 This section includes an engine schematic (figure 3-71) and electrical schematics (figure 3-72) of the J-2 engine systems for a reference for engine analysis and troubleshooting.



MCR NO.	TITLE	ZONE	ENG EFFECTIVITY	KIT EFFECTIVITY & KIT MD NO.
J2-711 MD 376	AIR FILLER VALVES CHANGES TO	5	J2066-1 J2039-1 J2046 & SUBS	40 KITS TBD MD 376
J2-689 MD 380 MD 381	INCORPORATION OF IMPROVED ELECTRICAL CONTROL ASSEMBY	11, 11.1 12.1, 13.3	J2039-1 J2046 & SUBS	7 KITS TBD MD 380 26 KITS TBD MD 381
J2-609 MD 316 MD 317	TWO POSITION MIXTURE RATIO CONTROL VALVE, INCORPORATION OF	5, 6.1	J2036-1, J2039-1, J2046 & SUBS	54 KITS TBD
J2-633 MD 340 MD 349	AIR FILLER VALVE ASSEMBLIES; MODIFICATION OF	5	J2141 - J2149	82 KITS TBD
J2-369 MD 151	TEMP TRANSDUCER, IMPROVEMENTS TO	5, 13.1	J2046 & SUBS	17 KITS TBD
J2-550 MD 262	TEMP TRANSDUCER, REMOVAL OF	5, 13.2	J2149 - J2150	NONE
J2-606 MD 324	IMPROVED TIMERS, ECA; INCORPORATION OF	11 13.2	J2140 & SUBS	102 KITS TBD J2031 THRU J2139
J2-624 MD 316	START TANK EMERGENCY VENT SYSTEM; ADDITION OF	5.9	J2145 & SUBS	24 KITS TBD J2025 & SUBS
J2-587 MD 291	MAINSTAGE OK PRESSURE SWITCHES, REIDENTIFICATION TO VERIFY HOT-FIRE TEST	5, 17, 17.1 & 17.2	J2130 & SUBS	NONE
J2-582 MD 259	IGNITION DETECTOR PROBE ASSY; X-RAY INSPECTION OF	5.16	J2104 & SUBS	NONE
J2-571 MD 259	SOLDER JOINTS ECA; INSPECTION OF	8-17.2	J2131 & SUBS	NONE
J2-570 MD 294	PRINTED CIRCUIT BOARDS, ECA; PROVIDE THERMAL STRESS RELIEF OF COMPONENT LEADS & CROSSOVER CLINCH LEADS ON	8-17.2	J2145 & SUBS	NONE
J2-566 MD 241	GERMANIUM TRANSISTOR ECA; REPLACEMENT OF	13.2, 17.2	J2122 & SUBS	NONE
J2-559 MD N/R	CONNECTOR ASSY; CHANGE FROM LOOSE EQUIPMENT TO KITS (REF J22)	5, 13	NONE	J2048 - J2051 J2053 - J2074
J2-546 MD 243	CIRCUIT BOARDS ELECTRICAL CONTROL ASSY; IMPROVEMENTS TO	2, 13.1 & 8-17.1	J2122 & SUBS	NONE
J2-510 MD 210	PRESSURE SWITCH CALIPS/MAINSTAGE; PERFORM CHECKOUT OF	5, 17, 17.1	J2058 & SUBS	23 KITS TBD MD 210
J2-469 MD 195	BONDING, ELECT CONTROLS ASSY; IMPROVEMENT TO	2, 5	J2078 & SUBS	J2037
J2-461 MD 204	CIRCUITRY, UNUSED, ELEC CONTROLS ASSY; DELETION OF	7.1, 10.1, 13.1, 14.1 & 17.1.5	J2075 & SUBS	NONE
J2-439 MD 205	TIMER, START TANK DISCHARGE DELAY; CHANGES	2, 7 & 13	J2066 & SUBS	NONE
J2-426 MD 185	ARMORED HARNESS ASSY; MODIFICATION TO	4	J2072 & SUBS	NONE
J2-432 MD 176	PRESSURIZATION TUBE, SPARK IGNITER & CABLE ASSEMBLY, GG. & ASI; TIG BRAZE WELD OF	5	PROD J2045 & SUBS	J2031 THRU J2044 MD 176
J2-422 MD 171	CONNECTORS, ARMORED HARNESS; IMPROVEMENTS TO	4	J2056 & SUBS	NONE
J2-419 MD 168	ARMORED HARNESS ASSY; REDESIGN OF	4	PROD J2047 & SUBS	J2031-J2047 MD 168
J2-410 MD 160	PRECHILL CONTROLLER; DELETE FUNCTION OF	5 & 13	J2048 & SUBS	14 KITS TBD MD 160
J2-404 MD 88	CABLES, ASI & GG IGNITER; ADDITION OF SHIELDING AND WRAPPING TO	5	J2031 & SUBS	NONE
J2-399 MD 163	PRESSURIZATION REQUIREMENTS, START TANK & HELIUM TANK; CHANGES TO	5 & 14	J2032, J2052 & SUBS	J2037 & 6 KITS TBD MD 163
J2-329R2 MD 338	IGN. DETECTOR, DUMMY, INCORP OF	16	NONE	92 KITS: 1 LT ING 3 TBD
J2-329 MD 133	IGN. DET PROBE, ASI, DUMMY; INCORP OF	16	NONE	15 KITS
J2-365 MD 142	IGNITION DETECTOR PROBE, FUSIBLE LINK; IMPROVEMENTS TO	5 & 16	J2031 & SUBS	NONE
J2-255 MD 88	CONTROL ASSY, ELECTRICAL; REDESIGN OF	1 THRU 17	J2031 & SUBS	TBD FOR FY 204 MD 182

(6) MCR RECORD

(8) 14. MAXIMUM VOLTAGE IS 32 VDC AT INITIAL VOLTAGE. APPLICATION FOR NO LONGER THAN 60 SECONDS.

(7) 13. MINIMUM VOLTAGE IS 24 VDC AT ANY ENGINE START UNTIL MAINSTAGE OK.

12. SYMBOL [XXX] & (XX) DENOTES ADDITION & DELETION RESPECTIVELY PER DASH NO. OF MCR INDICATED INSIDE SYMBOL

(6) 11. MCRS INCORPORATED PRIOR TO J2031 ARE SHOWN ON SCHEMATIC 502100.

10. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN; FOR COMPLETE DESIGNATION, PREFIX WITH UNIT NUMBER OR SUB-ASSEMBLY DESIGNATION(S)

9. UNDERLINED LETTERS DENOTE LOWER CASE

(5) 8. INDICATES BOND

7. SYMBOL ⏚ DENOTES ENGINE FRAME

(4) 6. ENERGIZE DURING COMPONENT TESTING TO PREVENT INADVERTANT SEQUENCING

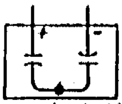
(3) 5. USE P54-Y FOR VOLTAGE SOURCE

(2) 4. IGNITION VOLTAGE LESS A MAX OF 4 VOLTS: CURRENT LIMITED BY 250 OHMS

(1) 3. CONTROL VOLTAGE LESS A MAX OF 4 VOLTS; CURRENT LIMITED BY 250 OHMS.

2. ALL ENGINE HARNESS WIRE 16GA UNLESS NOTED

1. ALL CONTROL ASSY WIRES 22GA UNLESS NOTED

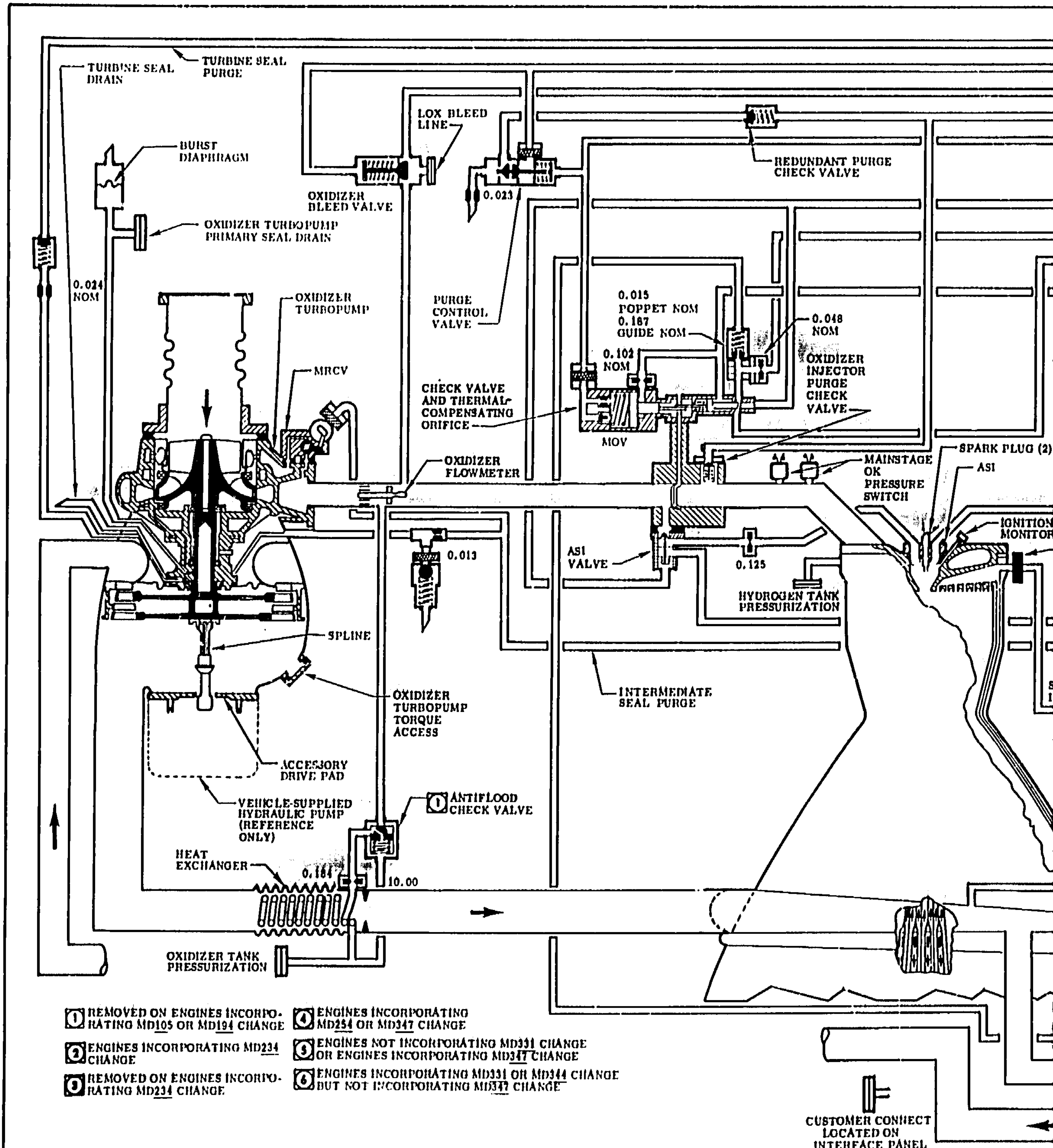


502652 CAPACITOR MODULE CIRCUIT, TWO NAS-2124673 (47 µfd 20VDC) CAPACITORS IN SERIES

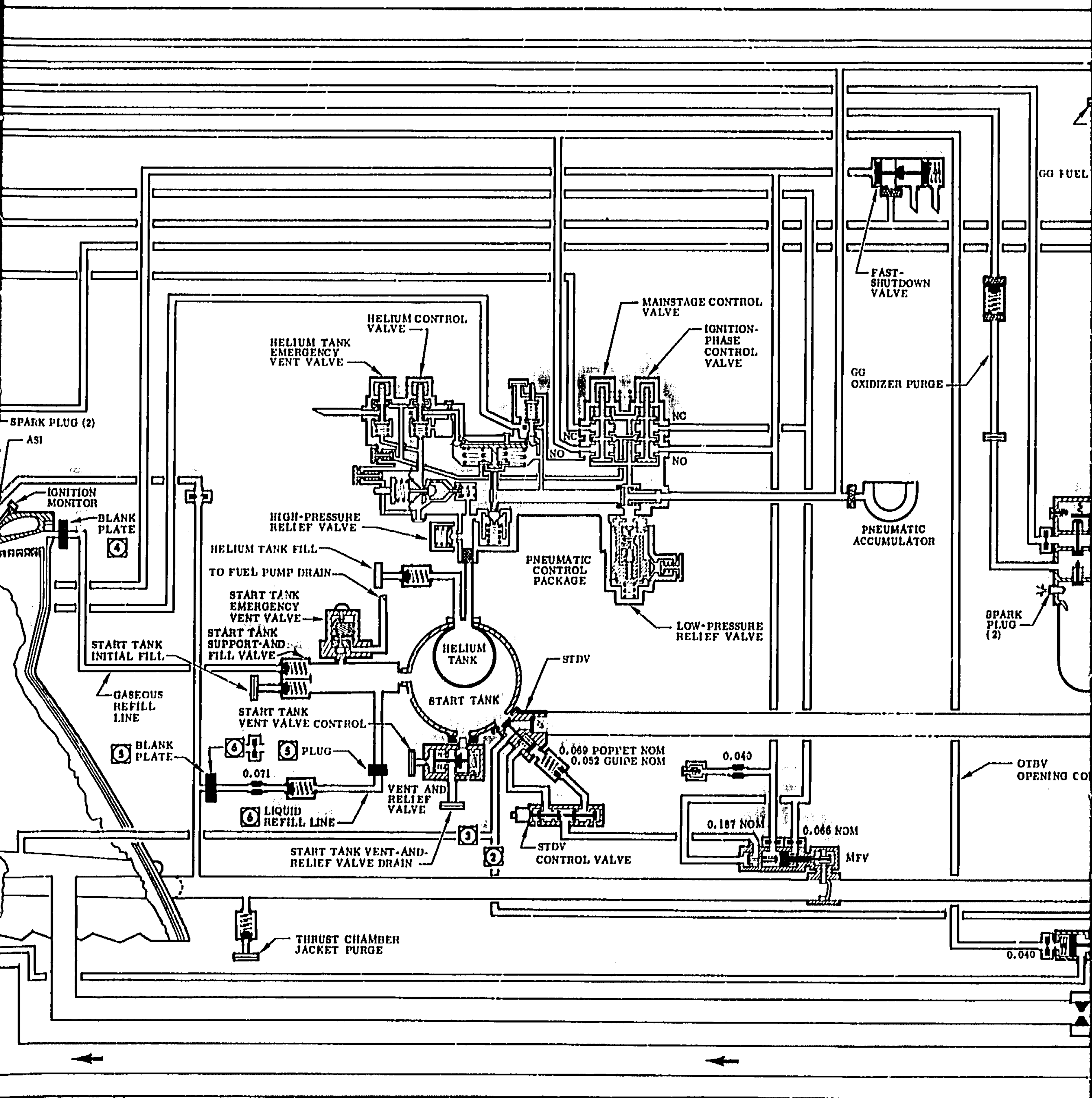
ZONE 1

J2-1B-59A

Figure 3-72. Engine Electrical Schematic (Sheet 1 of 24)



TURBINE SEAL DRAIN
TURBINE SEAL PURGE
BURST DIAPHRAGM
LOX BLEED LINE
OXIDIZER BLEED VALVE
0.023
REDUNDANT PURGE CHECK VALVE
OXIDIZER TURBOPUMP PRIMARY SEAL DRAIN
0.024 NOM
OXIDIZER TURBOPUMP
PURGE CONTROL VALVE
0.015 POPPET NOM
0.167 GUIDE NOM
0.048 NOM
0.102 NOM
MRCV
OXIDIZER INJECTOR PURGE CHECK VALVE
CHECK VALVE AND THERMAL-COMPENSATING ORIFICE
MOV
OXIDIZER FLOWMETER
MAINSTAGE OK PRESSURE SWITCH
SPARK PLUG (2)
ASI
IGNITION MONITOR
0.013
ASI VALVE
0.125
HYDROGEN TANK PRESSURIZATION
SPLINE
INTERMEDIATE SEAL PURGE
OXIDIZER TURBOPUMP TORQUE ACCESS
ACCESSORY DRIVE PAD
VEHICLE-SUPPLIED HYDRAULIC PUMP (REFERENCE ONLY)
1 ANTIFLOOD CHECK VALVE
HEAT EXCHANGER
0.164
10.00
OXIDIZER TANK PRESSURIZATION
1 REMOVED ON ENGINES INCORPORATING MD105 OR MD194 CHANGE
2 ENGINES INCORPORATING MD234 CHANGE
3 REMOVED ON ENGINES INCORPORATING MD234 CHANGE
4 ENGINES INCORPORATING MD254 OR MD347 CHANGE
5 ENGINES NOT INCORPORATING MD331 CHANGE OR ENGINES INCORPORATING MD347 CHANGE
6 ENGINES INCORPORATING MD331 OR MD344 CHANGE BUT NOT INCORPORATING MD347 CHANGE
CUSTOMER CONNECT LOCATED ON INTERFACE PANEL



GG FUEL
FAST-SHUTDOWN VALVE
MAINSTAGE CONTROL VALVE
IGNITION-PHASE CONTROL VALVE
HELIUM CONTROL VALVE
HELIUM TANK EMERGENCY VENT VALVE
GG OXIDIZER PURGE
SPARK PLUG (2)
ASI
NC
NO
IGNITION MONITOR
BLANK PLATE
4
HIGH-PRESSURE RELIEF VALVE
PNEUMATIC ACCUMULATOR
HELIUM TANK FILL
PNEUMATIC CONTROL PACKAGE
TO FUEL PUMP DRAIN
START TANK EMERGENCY VENT VALVE
SPARK PLUG (2)
LOW-PRESSURE RELIEF VALVE
START TANK SUPPORT-AND-FILL VALVE
START TANK INITIAL FILL
HELIUM TANK
STDV
GASEOUS REFILL LINE
START TANK
START TANK VENT VALVE CONTROL
5 BLANK PLATE
6
5 PLUG
0.069 POPPET NOM
0.052 GUIDE NOM
0.040
OTBV OPENING CO
0.071
VENT AND RELIEF VALVE
6 LIQUID REFILL LINE
0.187 NOM
0.066 NOM
3
START TANK VENT-AND-RELIEF VALVE DRAIN
2
STDV CONTROL VALVE
MFV
THRUST CHAMBER JACKET PURGE
0.040

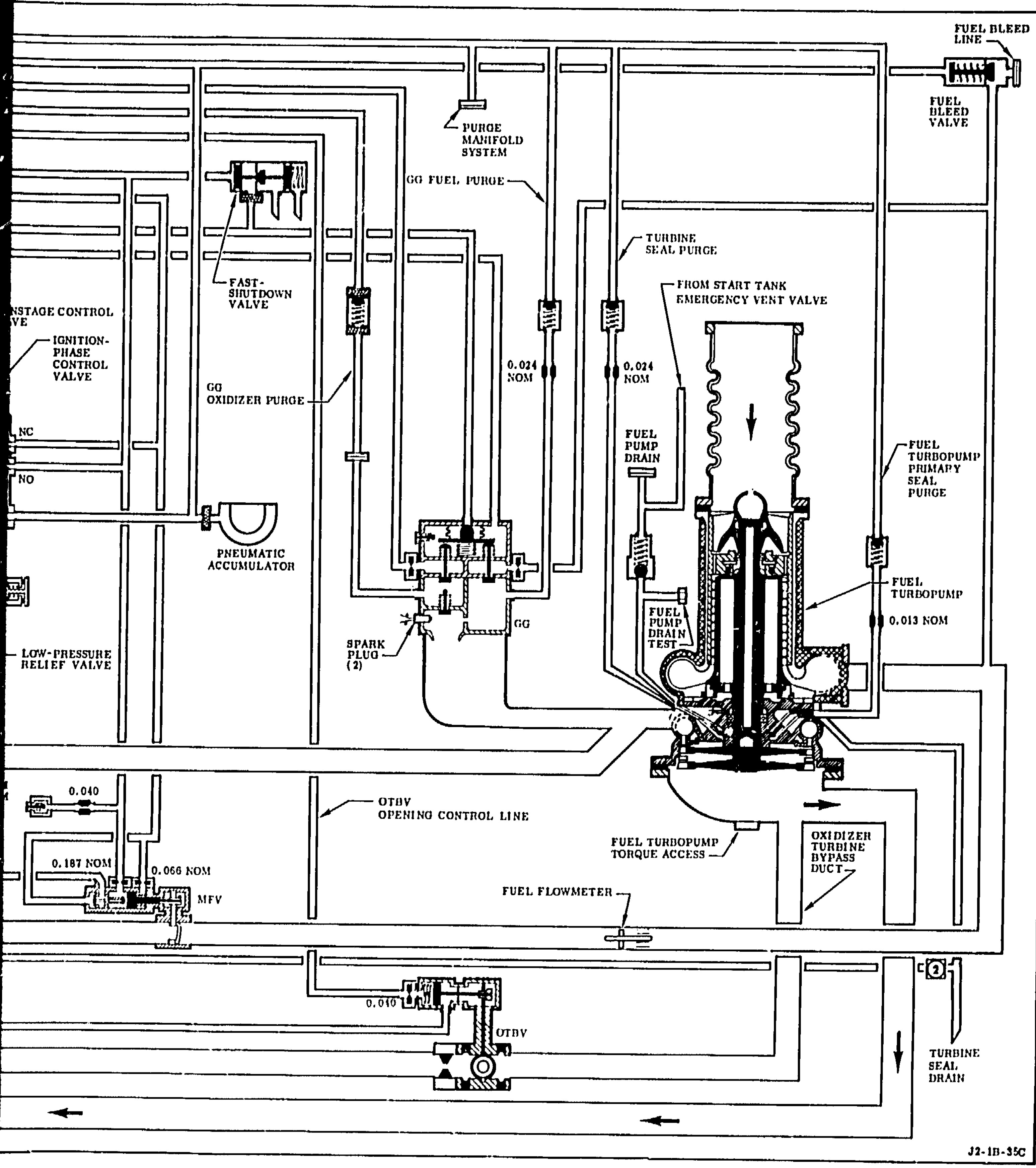


Figure 3-71. Engine Schematic

RESISTOR MODULE (461) 502648

ITEM NO	PART NO.	DESCRIPTION	ZONE
CR1-CR42	NAS-27251-T1	DIODE 3A 4W 600V	9-17
R1	NAS-27250T500D	RESISTOR 5KΩ 2W	9
R2	NAS-27250T1001M	1KΩ 2.25W	9
R3	NAS-27250T5001D	5KΩ 2W	9
R4	NAS-27250T1001M	1KΩ 2.25W	9
R5	NAS-27250T2500N	250Ω 4W	9
R6			9
R7			11
R8			12
R9			12
R10			13
R11			14
R12			14
R13			14
R14			15
R15			15
R16			10
R17	NAS-27250T2500N	250Ω 4W	16
R18	NAS-27250T5200M	520Ω 2.25W	17
R19	NAS-27250T2500N	250Ω 4W	17
R20	NAS-27250T2500V	250Ω 4W	17
R21	NAS-27250T2500N	RESISTOR 250Ω 4W	17

FILTER BOARD 502668

CR1	NAS-27270T6	DIODE 22VBD 10W	8
CR2	NAS-27270T6	DIODE 22VBD 10W	8
C1	NAS-27246T13	CAPACITOR 47μf 35V	8
C2	NAS-27246T13	CAPACITOR 47μf 35V	8
CR1, CR2	NAS-27374T22C	(ALLOWABLE ALTERNATE)	8

MISCELLANEOUS

(469)	G1-G4	NAS-27383	SPARK EXCITER	12
(469)	G1-G4	500752	SPARK EXCITER	12
	MT1-MT12	NAS-27315	TEMP TRANSDUCER	8

CUTOFF CONTROL NO. 1 502042 (511) 502642 (510)

ITEM NO	PART NO.	DESCRIPTION	ZONE
CR1	NAS-27319-T1	9.1VBD 4W DIODE ZENER	16
CR2-CR?	NAS-27251-T1	600V 4W 3A DIODE	16
Q1	NAS-27386	PNP TRANSISTOR	16
Q2	NAS-27263	NPN	
Q3	NAS-27386	PNP	
Q4	NAS-27386	PNP	
Q5	NAS-27263	NPN	
Q6	NAS-27263	NPN TRANSISTOR	16
R1	NAS-27250T1001M	RESISTOR 1KΩ 2.25W	16
R2	NAS-27250T5200M	520Ω 2.25W	
R3	NAS-27250T6000M	600Ω 2.25W	
R4	NAS-27266T5101Z	5.1KΩ 1/3 W	
R5	NAS-27266T5101Z	5.1KΩ 1/3 W	
R6	NAS-27266T1001Y	1KΩ 1/8 W	
R7	NAS-27250T1001M	1KΩ 2.25W	
R8	NAS-27266T5101Z	5.1KΩ 1/3W	
R9	NAS-27250T1001M	1KΩ 2.25W	
R10	NAS-27266T1001Y	1KΩ 1/8W	
R11	NAS-27266T1001Y	1KΩ 1/8W	
R12	NAS-27250T2001M	2KΩ 2.25W	
R13	NAS-27266T5101Z	5.1KΩ 1/3W	
R14	NAS-27266T1001Y	RESISTOR 1KΩ 1/8 W	16
C1	502652	CAPACITOR MODULE	16

CUTOFF CONTROL NO. 2 (461) 502643

C1-C4	502652	CAPACITOR MODULE	17
Q1-Q4	NAS-27263	NPN TRANSISTOR	17
Q5	NAS-27394T2	PNP TRANSISTOR	17
CR1-CR18	NAS-27251-T1	600V 4W 3A DIODE	17
CR19	NAS-27374-T5R6C	5.6VBD, 10W DIODE ZENER	17
CR20, CR21	NAS-27251-T1	600V 4W 3A DIODE	17
R1	NAS-27250T1001M	RESISTOR 1KΩ 2.25W	17
R2	NAS-27266T1001Y	1KΩ 1/8W	
R3	NAS-27250T5200M	520Ω 2.25W	
R4	NAS-27250T5200M	520Ω 2.25W	
R5	NAS-27250T1001M	1KΩ 2.25W	
R6	NAS-27266T1001Y	1KΩ 1/8W	
R7	NAS-27250T5200M	520Ω 2.25W	
R8	NAS-27250T1600M	160Ω 2.25W	
R9	NAS-27250T3600M	360Ω 2.25W	
R10	NAS-27250T1001M	1KΩ 2.25W	
R11	NAS-27266T1001Y	1KΩ 1/8W	
R12	NAS-27266T1001Y	1KΩ 1/8W	
R13	NAS-27250T5200M	520Ω 2.25W	
R14	NAS-27250T5200M	520Ω 2.25W	
R15	NAS-27266T2400Y	240Ω 1/8W	
R16	NAS-27266T1002Y	RESISTOR 10KΩ 1/8W	17

VALVE CONTROL 502046 (510) 501146 (546) (570) 502646 (546)

ITEM NO	PART NO.	DESCRIPTION	ZONE
CR1-CR31	NAS-27251-T1	600V 4W 3A DIODE	14,15
CR32	NAS-27374-T5R6C	5.6VBD, 10W ZENER	15
CR33	NAS-27319-T11	39VBD, 4W ZENER	15
CR34	NAS-27319-T11	39VBD, 4W ZENER	15
CR35	NAS-27374-T5R6C	5.6VBD, 10W ZENER	14
Q1	NAS-27263	NPN TRANSISTOR	15
Q2	NAS-27262	NPN	
* Q3	NAS-27442T1	PNP	
Q4	NAS-27263	NPN	
* Q5	NAS-27442T1	PNP	
Q6	NAS-27262	NPN	
Q7	NAS-27262	NPN	15
Q8	NAS-27263	NPN	14
Q9	NAS-27262	NPN	14
* Q10	NAS-27442T1	PNP TRANSISTOR	14
R1	NAS-27250T70R0M	RESISTOR 70Ω 2.25W	15
R2	NAS-27250T2000N	200Ω 4W	
R3	NAS-27266T1001Y	1KΩ 1/8W	
R4	NAS-27250T1001M	1KΩ 2.25W	
R5	NAS-27266T1001Y	1KΩ 1/8 W	
R6	NAS-27250T27R0C	27Ω 1W	
R7	NAS-27266T5101Z	5.1KΩ 1/3W	
R8	NAS-27250T1001M	1KΩ 2.25W	
R9	NAS-27266T1001Y	1KΩ 1/8W	
R10	NAS-27250T70R0M	70Ω 2.25W	
R11	NAS-27250T2000N	200Ω 4W	
R12	NAS-27266T1001Y	1KΩ 1/8W	
R13	NAS-27266T1001Y	1KΩ 1/8W	
R14	NAS-27250T27R0C	27Ω 1W	
R15	NAS-27266T5101Z	5.1KΩ 1/3W	15
R16	NAS-27250T1001M	1KΩ 2.25W	14
R17	NAS-27266T1001Y	1KΩ 1/8W	14
R18	NAS-27266T1001Y	1KΩ 1/8W	14
R19	NAS-27250T27R0C	27Ω 1W	14
R20	NAS-27266T5101Z	5.1KΩ 1/3W	14
R21	NAS-27398T90R0U	90Ω 15W	15
R22	NAS-27398T90R0U	90Ω 15W	15
R23	NAS-27398T2500U	250Ω 15W	15
R24	NAS-27398T2500V	250Ω 15W	14
R25	NAS-27398T90R0U	RESISTOR 90Ω 15W	14
*Q3,Q5,Q10	NAS-27252	PNP ALTERNATE TRANSISTOR	
C1-C5	502652	CAPACITOR MODULE	15
C6	502652	CAPACITOR MODULE	14

PROGRAMMER 502647 (459) 502647-11 (459) (461)

Q1	NAS-27386	PNP TRANSISTOR	13
Q2	NAS-27263	NPN	
Q3	NAS-27386	PNP	
Q4	NAS-27263	NPN	
Q5	NAS-27386	PNP	
Q6	NAS-27263	NPN	
Q7	NAS-27394-T2	PNP TRANSISTOR	13

PROGRAMMER (CONT)

ITEM NO	PART NO	DESCRIPTION	ZONE	
CR1	NAS-27319T1	9.1VBD, 4W ZENER	13	
CR2-CR11	NAS-27251-T1	600V 3A 4W	13	
R1	NAS-27384T5001	RESISTOR 0-5KΩ 1/2W	13	
R2	NAS-27250T2001M	2KΩ 2.25W		
R3	NAS-27250T6000M	600Ω 2.25W		
R4	NAS-27266T1001Y	1KΩ 1/4W		
R5	NAS-27384T5002	0-50KΩ 1/2W		
R6	NAS-27308T6852B	68.5KΩ 1/2W		
R7	NAS-27384T5002	0-50KΩ 1/2W		
R8	NAS-27308T3002B	30KΩ 1/2W		
R9	NAS-27384T5002	0-50KΩ 1/2W		
R10	NAS-27308T8002B	80KΩ 1/2W		(457)
R11	NAS-27250T1001M	1KΩ 2.25W		
R12	NAS-27266T1002Y	10KΩ 1/8W		
R13	NAS-27250T6000M	600Ω 2.25W		
R14	NAS-27250T2001M	2KΩ 2.25W		
R15	NAS-27250T2000N	200Ω 4 W		
R16	NAS-27250T1001M	1KΩ 2.25W		
R17	NAS-27266T5101Z	5.1KΩ 1/3 W		
R18	NAS-27266T1001Y	1KΩ 1/8W		
R19	NAS-27250T5200M	520Ω 2.25W		
R20	NAS-27266T1002Y	10KΩ 1/8W		
R21	NAS-27250T1001M	1KΩ 2.25W		
R22	NAS-27266T1001Y	1KΩ 1/8W		
R23	NAS-27266T2400Y	240Ω 1/8W		
R24	NAS-27250T1001M	1KΩ 2.25W		
R25	NAS-27250T1001M	1KΩ 2.25W		
R26	NAS-27250T1001M	1KΩ 2.25W		
R27	NAS-27250T1001M	1KΩ 2.25W		
R28	NAS-27250T1001M	RESISTOR 1KΩ 2.25W		
M1	NAS-27364-TC1B	TIMER .1-15SEC ±3%		
M2	NAS-27364-TC1B	TIMER .1-15SEC ±3%		
M3	NAS-27364-TC10B	TIMER 1-105SEC ±3%	13	
R10	NAS-27308T1803B	RESISTOR 180KΩ 1/2W	13	(459)
C1	502652	CAPACITOR MODULE	13	
C2	502652	CAPACITOR MODULE	13	

SPARK CONTROL 502044 (510) 501144 (546) (570) 502644 (546)

C1	502652	CAPACITOR MODULE	12
C2	502652	CAPACITOR MODULE	12
R1	NAS-27266T1001Y	RESISTOR 1KΩ 1/8W	12
R2	NAS-27266T1001Y	1KΩ 1/8W	
R3	NAS-27266T5101Z	5.1KΩ 1/3W	
R4			
R5			
R6	NAS-27266T5101Z	5.1KΩ 1/3W	
R7	NAS-27250T27R0C	27Ω 1W	
R8			
R9			
R10	NAS-27250T27R0C	27Ω 1W	
R11	NAS-27398T1300U	130Ω 15W	
R12	NAS-27398T1300U	130Ω 15W	
R13	NAS-27398T90R0U	90Ω 15W	
R14	NAS-27398T90R0U	90Ω 15W	
R15	NAS-27398T90R0U	90Ω 15W	
R16	NAS-27398T90R0U	RESISTOR 90Ω 15W	12
CR1-CR2	NAS-27374T5R6C	5.6VBD, 10W ZENER	12
CR3-CR34	NAS-27251-T1	600V, 4W, 3A DIODE	12
	(CONT ZONE 3)		

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ZONE 2

J2-1B-00A

Figure 3-72. Engine Electrical Schematic (Sheet 2 of 24)

SPARK CONTROL (CONT) 502644

ITEM NO	PART NO.	DESCRIPTION	ZONE
Q1	NAS-2744ZT1	TRANSISTOR PNP	12
Q2			
Q3			
Q4	NAS-2744ZT1	PNP	
Q5	NAS-27262	NPN	
Q6	NAS-27262	TRANSISTOR NPN	12
Q1-Q4	NAS-27252	PNP ALTERNATE TRANSISTOR	

ENGINE MONITOR 502645

CR1	NAS-2731971	DIODE 9.1VBD, 4W ZENER	10
CR2-CR36	NAS-27251-T1	DIODE 3A, 4W, 600V PIV	10
Q1	NAS-27263	TRANSISTOR NPN	10
Q2	NAS-27263	TRANSISTOR NPN	10
Q3	NAS-27386	TRANSISTOR PNP	10
R1	NAS-27250T5200M	RESISTOR 520Ω 2.25W	10
R2			
R3			
R4			
R5			
R6			
R7			
R8			
R9			
R10			
R11	NAS-27250T5200M	520Ω	
R12	NAS-27250T2001M	2KΩ	
R13	NAS-27250T2001M	2KΩ 2.25W	
R14	NAS-27266T1001Y	1KΩ 1/8W	
R15	NAS-27266T1002Y	10KΩ 1/8W	
R16	NAS-27250T5200M	520Ω 2.25W	
R17	NAS-27266T1001Y	RESISTOR 1KΩ 1/8W	10
C1	502652	CAPACITOR MODULE	10

ENGINE START

502041-101 606
502041 570 606
501141 546 570
502641 546

CR1	NAS-27374-T5R6C	DIODE 5.6VBD, 10W ZENER	11
CR2-CR19	NAS-27251-T1	DIODE 3A, 4W, 600V PIV	11
CR20	NAS-27374-T5R6C	DIODE 5.6VBD, 10W ZENER	11
Q1	NAS-27263	TRANSISTOR NPN	11
Q2	NAS-27262	NPN	
Q3	NAS-2744ZT1	PNP	
Q4	NAS-2744ZT1	PNP	
Q5	NAS-27262	TRANSISTOR NPN	11
Q3, Q4	NAS-27252	PNP ALTERNATE TRANSISTOR	
R1	NAS-27250T27R0C	RESISTOR 27Ω 1W	11
R2	NAS-27250T27R0C	27Ω 1W	
R3	NAS-27250T70R0M	70Ω 2.25W	
R4	NAS-27250T70R0M	70Ω 2.25W	
R5	NAS-27250T2000N	200Ω 4W	
R6	NAS-27250T2000N	200Ω 4W	
R7	NAS-27250T1001M	1KΩ 2.25W	
R8	NAS-27266T1001Y	1KΩ 1/8W	
R9	NAS-27266T1001Y	RESISTOR 1KΩ 1/8W	11

ENGINE START (CONT) 502641

ITEM NO.	PART NO.	DESCRIPTION	ZONE
R10	NAS-27266T5101Z	RESISTOR 51KΩ 1/8W	11
R11	NAS-27266T1001Y	1KΩ 1/8W	
R12	NAS-27308T2003B	200KΩ 1/2W	
R13	NAS-27398T90R0U	90Ω 15W	
R14	NAS-27398T90R0U	RESISTOR 90Ω 15W	11
C1-C3	502652	CAPACITOR MODULE	11
M1	NAS-27364-TC1D	TIMER .05-.105SEC ±10%	11 (606)
M1	NAS-27364-TA1D	TIMER .1-1.0SEC ±10%	11 (606)

CONNECTORS

ITEM NO.	PART NO.	PIN ARR	NO. PINS	ZONE
1A1J1	19-502958-3	32-7P	35	8-17
2W3P1		32-7S	35	8-17
1A1A1U1A	502640-3			11
1A1J2	19-502958-6	36-10S	48	8-17
2W2P2		36-10P	48	8-17
1A1A2J2A	502640-5			16
1A1J3	19-502958-2	28-21S	37	8-17
2W1P3		28-21P	37	8-17
1A1A3J3A	502640-9			17
1A1A3J3B	502640-7			17
1A1A4J4A	502640-13			12
1A1A1J5	PER NAS-27383	PER ARP670	1	12
1A10P5	PER NAS-27378	PER ARP670	1	12
1A1A5J5A	502640-17			10
1A1A5J5B	502640-15			10
1A1A1J6	PER NAS-27383	PER ARP670	1	12
1A11P6	PER NAS-27378	PER ARP670	1	12
1A1A6J6A	502640-23			14, 15
1A1A6J6B	502640-19			14
1A1A3J7	PER NAS-27383	PER ARP670	1	12
1A12P7	PER NAS-27396	PER ARP670	1	12
1A1A7J7A	502640-25			13
1A1A14J8	PER NAS-27383	PER ARP670	1	12
1A15P8	PER NAS-27396	PER ARP670	1	12
1A1A11J9	PER NAS-27383	14S-7P	3	12
1W1P9	PD414-1009-0016	14S-7S	3	12
1A1A12J10	PER NAS-27383	14S-7P	3	12
1W2P10	RD414-1009-0016	14S-7S	3	12
1A1A13J11	PER NAS-27383	14S-7P	3	12
1W3P11	RD414-1009-0016	14S-7S	3	12
1A1A16J12	PER NAS-27383	14S-7P	3	12
1W4P12	RD414-1009-0016	14S-7S	3	12
1A2J13		14S-2P	4	11
2W1P13		14S-2S	4	11
1A2J14		14S-2P	4	15
2W1P14		14S-2S	4	15
1A2J15		14S-2P	4	15
2W1P15		14S-2S	4	15
1A5J16		14S-5P	5	14
2W1P16		14S-5S	5	14
1A2J17		14S-2P	4	9
2W1P17		14S-2S	4	9

CONNECTORS (CONT)

ITEM NO.	PART NO.	PIN ARR	NO. PINS	ZONE
1A4J18		14S-2P	4	14
2W1P18		14S-2S	4	14
1A7J19		14S-6P	6	16
2W1P19		14S-6S	6	16
1A6J20		14S-5P	5	17
2W1P20		14S-5S	5	17
J21	502957	10SL-3P	3	10
1W1P21		10SL-3S	3	10
1A8J22		10SL-3P	3	13
2W1P22		10SL-3S	3	13
2W3P25		18-1S	10	9
1A3J36		20-29P	17	6
2W4P36		20-29S	17	6
2W4P38		20-29P	17	6
2W3P51		32-7P	35	8-17
2W2P54		36-10S	48	8-17
1A10J26		14S-5P	5	17
2W1P26		14S-5S	5	17
(606) 1A3J119		16S-1P	7	6
(606) 2W5P180	503173-41	10SL-3S	3	9
2W5P55	503173-71	12S-3S	3	9
(689) 2W4P36A	NAS-27466T1145	11-4S	4	6.1
(689) 2W4J36A	NAS-27502T2029P	20-29P	17	6.1

RESISTOR MODULE

501148-11 511
501148 546 511
502648-11 461 546

ITEM NO.	PART NO.	DESCRIPTION	ZONE
CR1-CR13	NAS-27251-T1	DIODE 3A 4W 600V	9-17.1
CR15-CR17	NAS-27251-T1	DIODE 3A 4W 600V	9-17.1
CR20-CR25	NAS-27251-T1	DIODE 3A 4W 600V	9-17.1
CR27-CR42	NAS-27251-T1	DIODE 3A 4W 600V	9-17.1
R1	NAS-27250T5001D	RESISTOR 5KΩ 2W	9
R2	T1001M	1KΩ 2.25W	9
R3	T5001D	5KΩ 2W	9
R4	T1001M	1KΩ 2.25W	9
R5	T2500N	250Ω 4W	9
R6			9
R7			11
R8			12
R9			12
R11			14
R14			15
R15			15
R17	T2500N	250Ω 4W	16
R18	T5200M	520Ω 2.25W	17.1
R19	T2500N	250Ω 4W	17.1
R20	T2500N	250Ω 4W	17.1
R21	NAS-27250T2500N	RESISTOR 250Ω 4W	17.1

CUTOFF CONTROL NO. 2 461 502643-11 566

C2-C4	502652	CAPACITOR MODULE	17.1
Q2-Q4	NAS27263	NPN TRANSISTOR	
Q5	NAS27394T2	PNP TRANSISTOR	
CR4-CR7	NAS-27251-T1	DIODE 3A 4W 600V	
CR12-CR18	NAS-27251-T1	DIODE 3A 4W 600V	
CR19	NAS-27374-T5R6C	DIODE, ZENER 5.6VBD 10W	
CR20 (CR21)	NAS-27251-T1	DIODE 3A 4W 600V	
R3	NAS-27250T5200M	RESISTOR 520Ω 2.25W	
R5	NAS-27250T1001M	1KΩ 2.25W	
R6	NAS-27266T1001Y	1KΩ 1/8W	
R7	NAS-27250T5200M	520Ω 2.25W	
R8	NAS-27250T1600M	160Ω 2.25W	
R9	NAS-27250T3600M	360Ω 2.25W	
R10	NAS-27250T1001M	1KΩ 2.25W	
R11	NAS-27266T1001Y	1KΩ 1/8W	
R12	NAS-27266T1001Y	1KΩ 1/8W	
R13	NAS-27250T5200M	520Ω 2.25W	
R14	NAS-27250T5200M	520Ω 2.25W	
R15	NAS-27266T2400Y	240Ω 1/8W	
R16	NAS-27266T1002Y	RESISTOR 10KΩ 1/8W	17.1

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ZONE 3

CUTOFF CONTROL NO. 2

502043-11 571
502043 566 571

C1-C3	502652	CAPACITOR MODULE	17.2
Q1-Q3	NAS-27263	NPN TRANSISTOR	
Q4	NAS-27386	PNP TRANSISTOR	
Q5	NAS-27262	NPN TRANSISTOR	
CR1	NAS-27374-T5R6C	DIODE, ZENER 5.6VDC 10W	
CR2-CR13	NAS-27251-T1	DIODE 3A 4W 600V	
R1	NAS-27250T5200M	RESISTOR 520Ω 2.25W	
R2	NAS-27250T5200M	520Ω 2.25W	
R3	NAS-27250T1001M	1KΩ 2.25W	
R4	NAS-27266T1001Y	1KΩ 1/8W	
R5	NAS-27250T1600M	160Ω 2.25W	
R6	NAS-27250T3600M	360Ω 2.25W	
R7	NAS-27250T1001M	1KΩ 2.25W	
R8	NAS-27266T1001Y	1KΩ 1/8W	
R9	NAS-27266T1001Y	1KΩ 1/8W	
R10	NAS-27250T2001M	2KΩ 2.25W	
R11	NAS-27266T1001Y	1KΩ 1/8W	
R12	NAS-27266T1002Y	RESISTOR 10KΩ 1/8W	17.2

PROGRAMMER 461 502647-21 566

ITEM NO.	PART NO.	DESCRIPTION	ZONE
Q6	NAS-27263	NPN TRANSISTOR	13.1
Q7	NAS-27394-T2	PNP TRANSISTOR	
CR5-CR5	NAS-27251-T1	DIODE 3A 4W 600V	
CR7-CR9	NAS-27251-T1	DIODE 3A 4W 600V	
R5	NAS-27384T5002	RESISTOR 0-50KΩ 1/2W	
R6	NAS-27308T6852B	68.5KΩ 1/2W	
R7	NAS-27384T5002	0-50KΩ 1/2W	
R8	NAS-27308T3002B	30KΩ 1/2W	
R9	NAS-27384T5002	0-50KΩ 1/2W	
R10	NAS-27308T1803B	180KΩ 1/2W	
R20	NAS-27266T1002Y	10KΩ 1/8W	
R21	NAS-27250T1001M	1KΩ 2.25W	
R22	NAS-27266T1001Y	1KΩ 1/8W	
R23	NAS-27266T2400Y	240Ω 1/8W	
R24	NAS-27250T1001M	1KΩ 2.25W	
R25	NAS-27250T1001M	1KΩ 2.25W	
R27	NAS-27250T1001M	1KΩ 2.25W	
R28	NAS-27250T1001M	RESISTOR 1KΩ 2.25W	
M1	NAS-27364-TC1B	TIMER .1-1SEC ±3%	
M2	NAS-27364-TC1B	TIMER .1-1SEC ±3%	
M3	NAS-27364-TC10B	TIMER 1-10 SEC ±3%	
C2	502652	CAPACITOR MODULE	13.1

ENGINE MONITOR

502045 570
502645-21 511 570
502645-11 461 511

CR1	NAS-27391T1	DIODE ZENER 9.1VBD 4W	10.1
CR2	NAS-27251-T1	DIODE 3A 4W 600V	
CR5-CR9	NAS-27251-T1	DIODE 3A 4W 600V	
CR12-CR34	NAS-27251-T1	DIODE 3A 4W 600V	
Q1, Q2	NAS-27263	NPN TRANSISTOR	
Q3	NAS-27386	PNP TRANSISTOR	
R1	NAS-27250T5200M	RESISTOR 520Ω 2.25W	
R4	T5200M		
R5	T5200M		
R6	T5200M		
R7	T5200M		
R10	T5200M		
R11	NAS-27250T5200M	520Ω 2.25W	
R12	NAS-27250T2001M	2KΩ 2.25W	
R13	NAS-27266T2001Y	2KΩ 1/8W	
R14	NAS-27266T1001Y	1KΩ 1/8W	
R15	NAS-27266T1002Y	10KΩ 1/8W	
R16	NAS-27250T5200M	520Ω 2.25W	
R17	NAS-27266T1001Y	RESISTOR 1KΩ 1/8W	
C1	502652	CAPACITOR MODULE	10.1

PROGRAMMER

502047-111 606
502047-11 571 606
502047 566 571

ITEM NO.	PART NO.	DESCRIPTION	ZONE
Q1	NAS-27263	NPN TRANSISTOR	13.2
Q2	NAS-27386	PNP TRANSISTOR	
Q3	NAS-27262	NPN TRANSISTOR	
CR1-CR4	NAS-27251-T1	DIODE 3A 4W 600V	
R1	NAS-27250T1001M	RESISTOR 1KΩ 2.25W	
R2	NAS-27250T2001M	2KΩ 2.25W	
R3	NAS-27266T1001Y	1KΩ 1/8W	
R4	NAS-27250T2001M	2KΩ 2.25W	
R5	NAS-27384T5002	0-50KΩ 1/2W	
R6	NAS-27308T6852B	68.5KΩ 1/2W	
R7	NAS-27384T5002	0-50KΩ 1/2W	
R8	NAS-27308T3002B	30KΩ 1/2W	
R9	NAS-27384T5002	0-50KΩ 1/2W	
R10	NAS-27308T1803B	180KΩ 1/2W	
R11	NAS-27266T1002Y	10KΩ 1/8W	
R12	NAS-27266T1001Y	RESISTOR 1KΩ 1/8W	
M1	NAS-27364-TC1B	TIMER .1-1SEC ±3%	(606)
M2	NAS-27364-TC1B	TIMER .1-1SEC ±3%	(606)
M3	NAS-27364-TC10B	TIMER 1-10SEC ±3%	(606)
C1	502652	CAPACITOR MODULE	
M1	NAS-27364TA1B	TIMER .1-1SEC ±3%	(606)
M2	NAS-27364TA1B	TIMER .1-1SEC ±3%	(606)
M3	NAS-27364TA10B	TIMER 1-10SEC ±3%	13.2 (606)

J2-1B-01A

Figure 3-72. Engine Electrical Schematic (Sheet 3 of 24)

ENGINE START
501841-11
501841

ITEM NO	PART NO	DESCRIPTION	ZONE
CR1 & CR20	NAS-2737475P6C	DIODE 5.6 VBD 10W ZENER	11.1
CR2-CR19	NAS-2125171	DIODE 3A 4W 600V PIV	
CR21 & CR22	NAS-2725171	DIODE 3A 4W 600V PIV	
M1A & M1B	NAS-21504T1R0D	TIMER 1.0 SEC ±15%	
CR2-CR19	NAS-2750171	DIODE 3A 4W 600 PIV	
CR21 & CR22	NAS-2750171	DIODE 3A 4W 600 PIV	
M1A & M1B	NAS-21504T1R0D	TIMER 1.0 SEC ±10%	
Q1 & Q6	S2N4863	TRANSISTOR NPN	
Q2 & Q5	NAS-27262	TRANSISTOR NPN	
Q3 & Q4	NAS-2744271	TRANSISTOR PNP	
R1 & R2	NAS-27510T27R0C	RESISTOR 27Ω 1W	
R3 & R4	NAS-27510T76R0M	76Ω 2.25W	
R5 & R6	NAS-27510T2500M	250Ω 4W	
R7 & R15	NAS-27510T1001M	1KΩ 2.25W	
R8, R9, R11 & R12	NAS-27266T1001Y	1KΩ 1/8W	
R10	NAS-27266T5101Z	51KΩ 1/8W	
R13 & R14	NAS-27398T90R0U	RESISTOR 90Ω 15W	
C1-C3	502652	CAPACITOR MODULE	11.1

CUTOFF CONTROL NO.2
502043-31
502043-21

ITEM NO	PART NO	DESCRIPTION	ZONE
C1-C3	502652	CAPACITOR MODULE	17.2
CR1	NAS-2737475P6C	DIODE ZENER 5.6V 10W	
CR2-CR11	NAS-2750171	DIODE 3A 4W 600V	
Q1-Q3	S2N4863	TRANSISTOR NPN	
Q4	NAS-27336	TRANSISTOR PNP	
Q5	NAS-27262	TRANSISTOR NPN	
R2	NAS-27510T3260M	RESISTOR 326Ω 2.25W	
R3 & R7	NAS-27510T1500M	150Ω 2.25W	
R4, R8, R9 & R11	NAS-27266T1001Y	1KΩ 1/8W	
R5	NAS-27510T1600M	160Ω 2.25W	
R6	NAS-27510T3600M	360Ω 2.25W	
R10	NAS-27510T2001M	2KΩ 2.25W	
R12	NAS-27266T1002Y	RESISTOR 10KΩ 1/8W	17.2

FILTER BOARD
502668

ITEM NO	PART NO	DESCRIPTION	ZONE
CR1	NAS-2727076	DIODE 22VBD 10W	8
CR2	NAS-2727076	DIODE 22VBD 10W	8
C1	NAS-27245T13	CAPACITOR 47μF 15V	4
C2	NAS-27245T13	CAPACITOR 47μF 15V	4

SPARK CONTROL
502044
501144
501144-11

ITEM NO	PART NO	DESCRIPTION	ZONE
C1 & C2	502652	CAPACITOR MODULE	12
CR1 & CR2	NAS-2737475P6C	DIODE 5.6VBD 10W ZENER	12
CR3-CR18	NAS-2750171	DIODE 3A 4W 600 PIV	12
Q1-Q4	NAS-2744271	TRANSISTOR PNP	12
Q5-Q6	NAS-27262	TRANSISTOR NPN	12
R1 & R2	NAS-27266T1001Y	RESISTOR 1KΩ 1/8W	12
R3, R4, R5 & R6	NAS-27266T5101Z	5.1KΩ 1/8W	12
R7, R8, R9 & R10	NAS-27510T27R0C	27Ω 1W	12
R11 & R12	NAS-27398T1300U	130Ω 15W	12
R13, R14, R15 & R16	NAS-27398T90R0U	RESISTOR 90Ω 15W	12

ENGINE MONITOR
502045-11
502645-31
502645-41

ITEM NO	PART NO	DESCRIPTION	ZONE
C1	502652	CAPACITOR MODULE	10.1
CR1	NAS-2731971	DIODE 91.7VBD 4W ZENER	10.1
CR2	NAS-2750171	DIODE 3A 4W 600V PIV	10.1
CR3-CR9	NAS-2750171	DIODE 3A 4W 600V PIV	10.1
CR12-CR16	NAS-2750171	DIODE 3A 4W 600V PIV	10.1
Q1 & Q2	S2N4863	TRANSISTOR NPN	10.1
Q3	NAS-27336	TRANSISTOR PNP	10.1
R1	NAS-27510T5230M	RESISTOR 523Ω 2.25W	10.1
R4-R7			
R10			
R11			
R16	NAS-27510T3230M	323Ω 2.25W	10.1
R12	NAS-27510T2001M	2KΩ 2.25W	10.1
R14 & R17	NAS-27266T1001Y	1KΩ 1/8W	10.1
R15	NAS-27266T1002Y	RESISTOR 10KΩ 1/8W	10.1
R13	NAS-27266T2001Y	RESISTOR 2KΩ 1/8W	10.1

RESISTOR MODULE
501148
501148-11

ITEM NO	PART NO	DESCRIPTION	ZONE
CR1-CR13	NAS-2750171	DIODE 3A 4W 600V PIV	9, 17.1
CR15-CR17			
CR23-CR25			
CR27-CR42	NAS-2750171	DIODE 3A 4W 600V PIV	9, 17.1
R1 & R3	NAS-27510T5001D	RESISTOR 5KΩ 2W	9
R2 & R4	NAS-27510T1001M	1KΩ 2.25W	9
R5-R7	NAS-27510T2500M	250Ω 4W	9, 11, 11.1, 12
R11-R14			14, 15
R15-R17			15, 16
R19-R21	NAS-27510T2500M	250Ω 4W	17.1
R18	NAS-27510T5230M	RESISTOR 523Ω 2.25W	17.1

VALVE CONTROL
502046-11
501146-21
501146-31

ITEM NO	PART NO	DESCRIPTION	ZONE
C1-C6	502652	CAPACITOR MODULE	14.15
CR1-CR31	NAS-2750171	DIODE 3A 4W 600V PIV	14.15
CR32 & CR33	NAS-2737475P6C	DIODE 5.6VBD 10W ZENER	14.15
CR33 & CR34	NAS-2731971	DIODE 39VBD 4W ZENER	15
Q1, Q4, Q8	S2N4863	TRANSISTOR NPN	15
Q2, Q6, Q7, Q9	NAS-27262	TRANSISTOR NPN	14.15
Q3, Q5, Q10	NAS-2744271	TRANSISTOR PNP	14.15
R1 & R10	NAS-27510T70R0M	RESISTOR 70Ω 2.25W	15
R2 & R11	NAS-27510T2500M	250Ω 4W	15
R3, R5, R9, R12, R13, R17, R18	NAS-27266T1001Y	1KΩ 1/8W	14.15
R4, R8, R16	NAS-27510T1001M	1KΩ 2.25W	14.15
R6, R14, R19	NAS-27510T27R0C	27Ω 1W	14.15
R7, R15, R20	NAS-27266T5101Z	5.1KΩ 1/8W	14.15
R21, R22, R25	NAS-27398T90R0U	90Ω 15W	14.15
R23 & R24	NAS-27398T2500U	RESISTOR 250Ω 15W	14.15

PROGRAMER
501847-21
501847-11

ITEM NO	PART NO	DESCRIPTION	ZONE
C1	502652	CAPACITOR MODULE	13.3
CR1-CR13	NAS-2725171	DIODE 3A 4W 600V PIV	
M1A-M1C	NAS-27504TA1R0B	TIMER 1.0 SEC ±3%	
M2A-M2C	NAS-27504TAR45B	TIMER .45 SEC ±3%	
M3A-M3C	NAS-27504TA3R3B	TIMER 3.3 SEC ±3%	
CR1-CR15	NAS-2750171	DIODE 3A 4W 600V PIV	
M1A-M1C	NAS-27504TA1R0B	TIMER 1.0 SEC ±3%	
M2A-M2C	NAS-27504TAR45B	TIMER .45 SEC ±3%	
M3A-M3C	NAS-27504TA3R3B	TIMER 3.3 SEC ±3%	
Q1 & Q4	S2N4863	TRANSISTOR NPN	
Q2 & Q3	NAS-27262	TRANSISTOR NPN	
Q5	NAS-27336	TRANSISTOR PNP	
R1 & R3	NAS-27510T1001M	RESISTOR 1KΩ 2.25W	
R2, R7 & R8	NAS-27266T1001Y	1KΩ 1/8W	
R4 & R6	NAS-27510T2001M	2KΩ 2.25W	
R5 & R9	NAS-27266T1002Y	RESISTOR 10KΩ 1/8W	13.3

MULTIPLEX MODULE
501830-11
501830

ITEM NO	PART NO	DESCRIPTION	ZONE
CR1-CR23	NAS-27439T01	DIODE .75W 600PIV	13.3
CR24-CR26	NAS-27431T20	DIODE 20VBD 1W	
CR1-CR23	NAS-27439T01	DIODE .75W 600PIV	
CR24-CR26	NAS-27439T20	DIODE 20VBD 1W	
R1, R5, R9	[illegible]	RESISTOR 174KΩ 1/8W	
R3, R4, R7	[illegible]	22KΩ 1/8W	
R8, R11, R12	[illegible]	20KΩ 1/8W	
R13, R14	[illegible]	453KΩ 1/8W	
R2, R6, R10	NAS-27493T4530F	RESISTOR 453Ω 1W	13.3

MISCELLANEOUS

ITEM NO	PART NO	DESCRIPTION	ZONE
G1-G4	500752	SPARK EXCITER	12
G1-G4	500752-11	SPARK EXCITER	12
MT1 & MT2	NAS-27375	TEMP TRANSDUCER	5

SN NO 380
SN NO 391

CONNECTORS

ITEM NO	PART NO	PIN REF	NO PINS	ZONE
1A1J1	19-502958-3	32-7P	35	6-17.2
2W3P1		32-7S	35	6-17.2
1A1A1J1A	502640-3			11
1A1J2	19-502959-6	36-10S	48	8-11.2
2W2P2		36-10P	48	8-11.2
1A1A2J2A	502640-5			16
1A1J3	19-502958-2	28-21S	37	7-17.2
2W1P3		28-21P	37	7-17.2
1A1A3J3A	502640-9			17-17.2
1A1A3J3B	502640-7			17-17.2
1A1A4J4A	502640-13			12
1A1A11J5	PER NAS-27383	PER APP670	1	12
1A1P5	PER NAS-27378	PER APP670	1	12
1A1A5J5A	502640-17			10
1A1A5J5B	502640-15			10
1A1A12J6	PER NAS-27383	PER APP670	1	12
1A1P6	PER NAS-27378	PER APP670	1	12
1A1A6J6A	502640-23			14.15
1A1A6J6B	502640-19			14
1A1A13J7	PER NAS-27383	PER APP670	1	12
1A1P7	PER NAS-27376	PER APP670	1	12
1A1A7J7A	502640-25			13-13.3
1A1A14J8	PER NAS-27383	PER APP670	7	12
1A1P8	PER NAS-27376	PER APP670	1	12
1A1A11J9	PER NAS-27383	14S-7P	3	12
1W1P9	RDA14-1019-0016	14S-7S	3	12
1A1A12J10	PER NAS-27383	14S-7P	3	12
1W2P10	RDA14-1019-0016	14S-7S	3	12
1A1A13J11	PER NAS-27383	14S-7P	3	12
1W3P11	RDA14-1019-0016	14S-7S	3	12
1A1A4J12	PER NAS-27383	14S-7P	3	12
1W4P12	RDA14-1019-0016	14S-7S	3	12
1A8J13		14S-2P	4	11
2W1P13		14S-2S	4	11
1A2J14		14S-2P	4	15
2W1P14		14S-2S	4	15
1A2J15		14S-2P	4	15
2W1P15		14S-2S	4	15
1A5J16		14S-5P	5	14
2W1P16		14S-5S	5	14
1A2J17		14S-2P	4	9
2W1P17		14S-2S	4	9
1A4J18		14S-2P	4	14
2W1P18		14S-2S	4	14
1A7J19		14S-6P	6	16
2W1P19		14S-6S	6	16
1A6J20		14S-5P	5	17
2W1P20		14S-5S	5	17
J21	502957	10SL-3P	3	16
1W1P21		10SL-3S	3	16
1A9J22		10SL-3P	3	13-13.3
2W1P22		10SL-3S	3	13-13.3
2W3P25		18-1S	10	9
1A3J36		20-29P	17	6 6.1
2W1P36		20-29S	17	6 6.1
2W4P39		20-29P	17	6 6.1
2W3P51		32-7P	35	8-17.2
2W2P49		36-10S	48	8-11.2
1A10J26		14S-5P	5	17-17.2
2W1P26		14S-5S	5	17-17.2
2W5P193	503173-41	10SL-3S	3	9
2W5P35	503173-11	12S-3S	3	9
2W4P31A	NAS-27416T1145	11-4S	4	6.1
2W4P36A	NAS-27592T2029P	20-29P	17	6.1

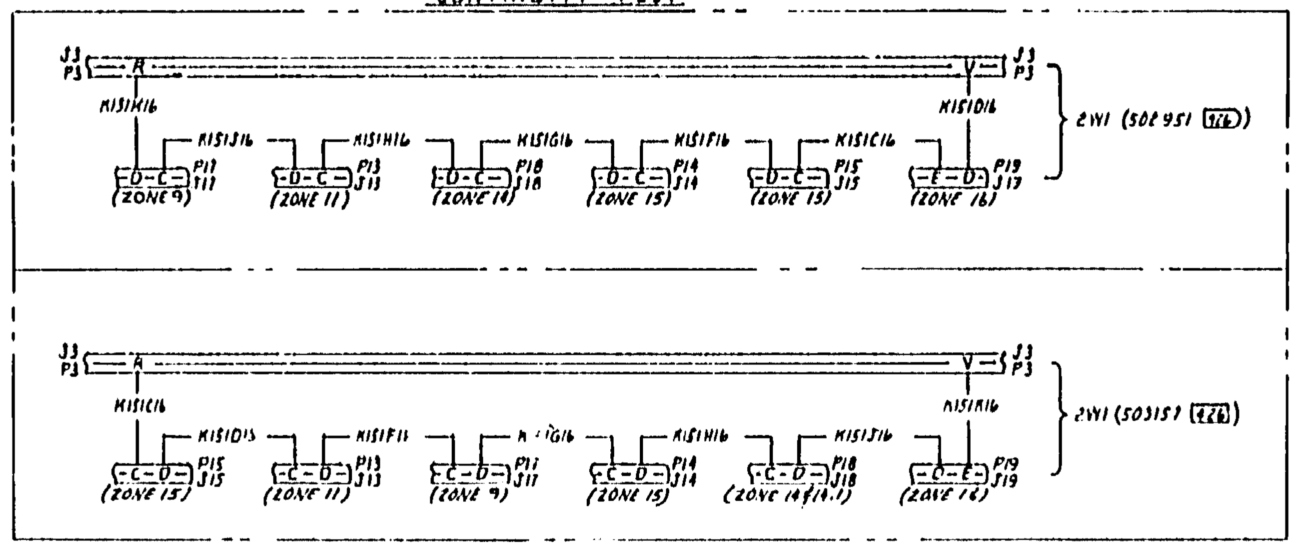
THIS ZONE ADDED BY [108]

ZONE 3.1

J2-1B-103

Figure 3-72. Engine Electrical Schematic (Sheet 3A of 24)

— CONTINUITY TEST —



CABLE INFORMATION

CABLE (REF)	PART NO	APPLICABLE MCR'S	ACTUAL EFFECTIVITY
2W5	502265	624	

CABLE (REF)	PART NO.	APPLICABLE MCR'S	ACTUAL EFFECTIVITY
2W1	502951	422	J2031 - J2055
2W1	502951-11	422 426	J2056 - J2071
2W1	503157	426	J2072 & SUBS

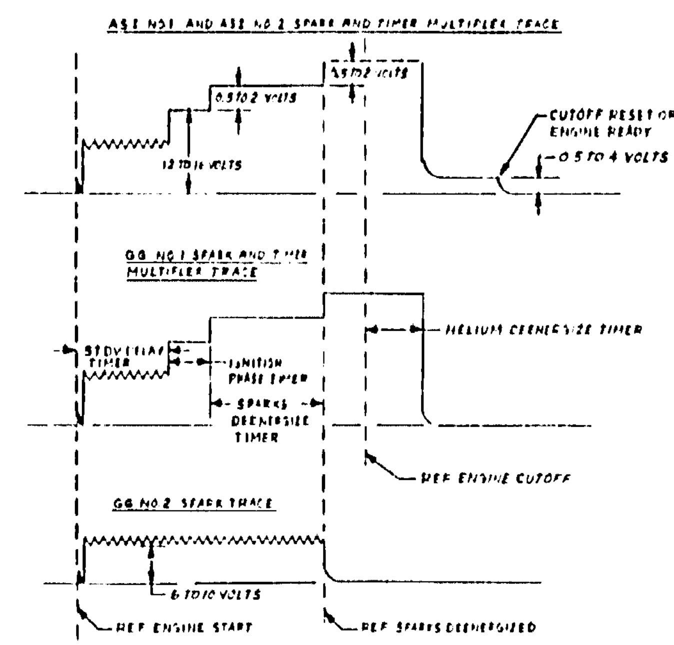
CABLE (REF)	PART NO.	APPLICABLE MCR'S	ACTUAL EFFECTIVITY
2W2	502168	419	
2W2	503166	419 422	J2031 - J2055
2W2	503166-11	422 426	J2056 - J2071
2W2	503158	426	J2072 & SUBS

CABLE (REF)	PART NO.	APPLICABLE MCR'S	ACTUAL EFFECTIVITY
2W3	502016 11	419	
2W3	503165	419 422	J2031 - J2055
2W3	503165-11	422 426	J2056 - J2071
2W3	503160	426	J2072 & SUBS

CABLE (REF)	PART NO.	APPLICABLE MCR'S	ACTUAL EFFECTIVITY
2W4	502018-11	419	
2W4	503164	419 422	J2031 - J2055
2W4	503164-11	422 426	J2056 - J2071
2W4	503159	426	J2072 & SUBS
2W4	503266	689	

ENGINEERING INFORMATION

ELECTRICAL CONTROLS ASSY	PRODUCTION EFFECTIVITY	RETROFIT EFFECTIVITY	
502670	J2031 - J2065	J2016 & J2025	453
502670-11	J2066-J2071	J2026, J2028, J2030 J2035, J2037, J2038, J2040, J2041, J2043- J2045, J2046, J2047- J2051, J2053, J2055 J2057-J2059, J2063- J2065	472 473 522
502670-21	J2075-J2077	J2026-1, J2030-1, J2073	481 473 526
502670-31	NONE	J2037	[illegible]
502670-51	[illegible]	J2036-1, J2030-1	[illegible]
502670-61	[illegible]	J2037 & J2073	[illegible]
502670-71	[illegible]	NONE	571 570 602
502670-81	NONE	NONE	570 600 [illegible]
502670-111	NONE	J2033, J2033-1, J2038-J2042, J2044-J2061, J2062-J2071, J2074	600 633
502670-[illegible]	NONE	J2015 - J2077	608 633
502670-[illegible]	NONE	J2062, [illegible]	608 633
502670-[illegible]	NONE	J2034, J2072, J2122 - J2130	[illegible] 633
502670-171	[illegible]	J2131 - J2133	608 633
502670-[illegible]	[illegible]	NONE	608 633
502670-211	NONE	J2014-1, J2019 & J2046 J2140, [illegible] J2110, J2062-J2065, J2074	633 711
502670-221	NONE	J2075 - J2077	633
502670-251	NONE	J2018-J2093, J2095-J2121	633 711
502670-261	NONE	J2031, J2075, J2122-J2130	633 711
502670-271	J2141-J2144	J2132 - J2140	633 711
502675-411, -431, -511, -451	NONE	J2036-1, J2039-1, J2046 & SUBS	711 705
502670-3,1, -311-391	NONE	J2039-1, J2046 & SUBS	705
502670-561, -571, -581	NONE	J2039-1, J2046 & SUBS	709



SPARK MONITOR AND TIMER MULTIPLEX OUTPUT
10K Ω MIN LOAD REF. ZONE 12.1

ZONE 4

J2-1B-62A

Figure 3-72. Engine Electrical Schematic (Sheet 4 of 24)

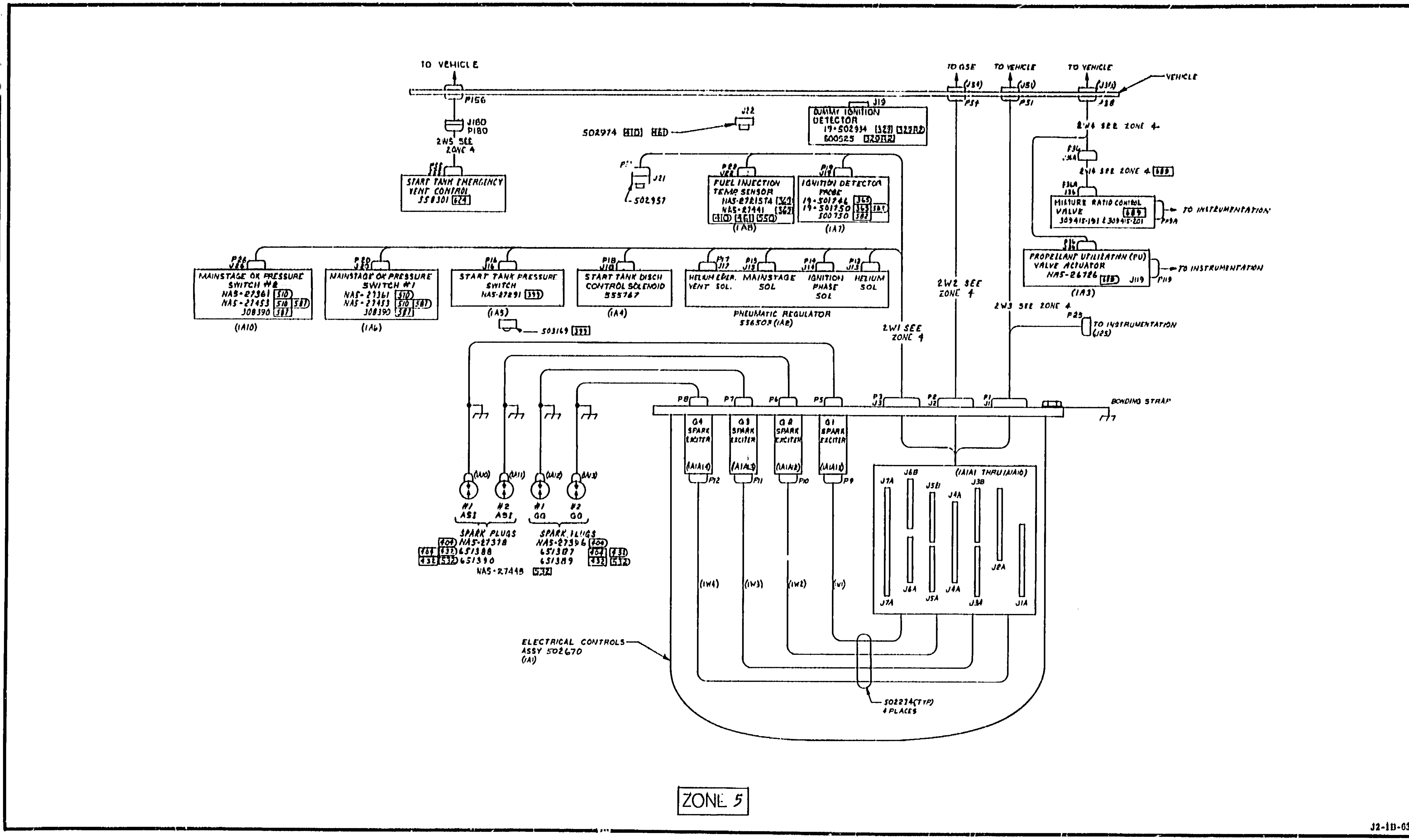


Figure 3-72. Engine Electrical Schematic (Sheet 5 of 24)

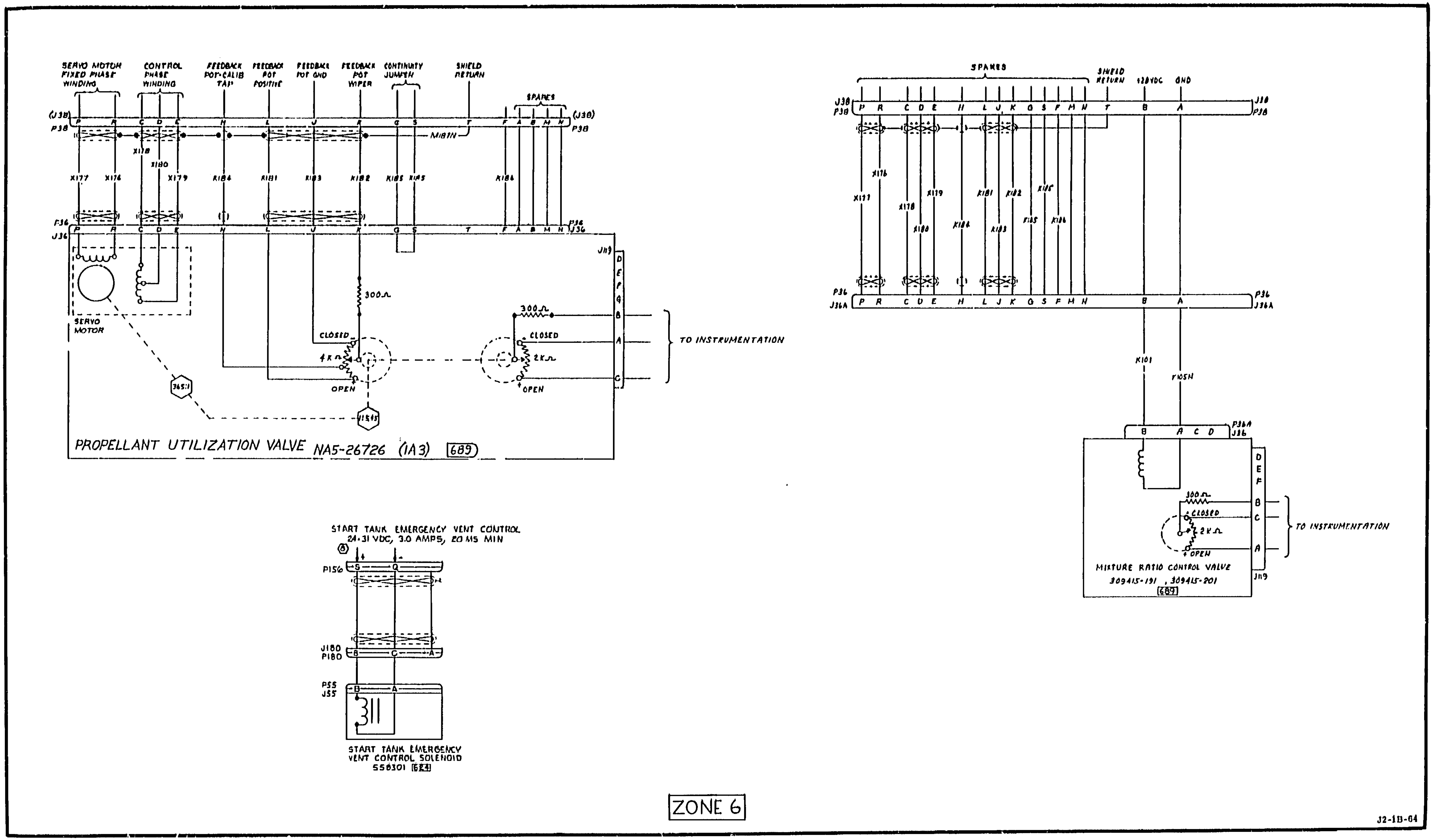


Figure 3-72. Engine Electrical Schematic (Sheet 6 of 24)

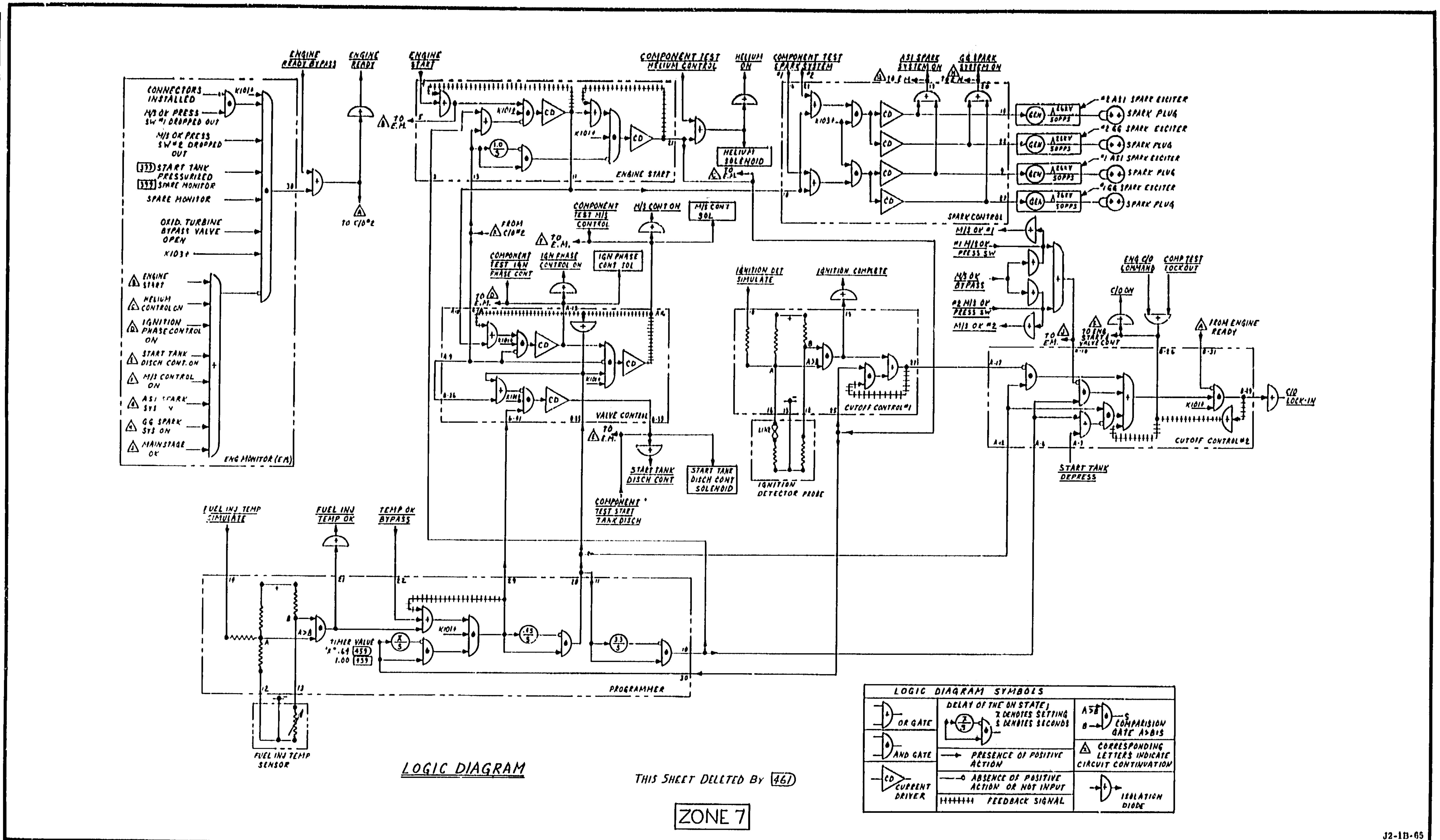


Figure 3-72. Engine Electrical Schematic (Sheet 7 of 24)

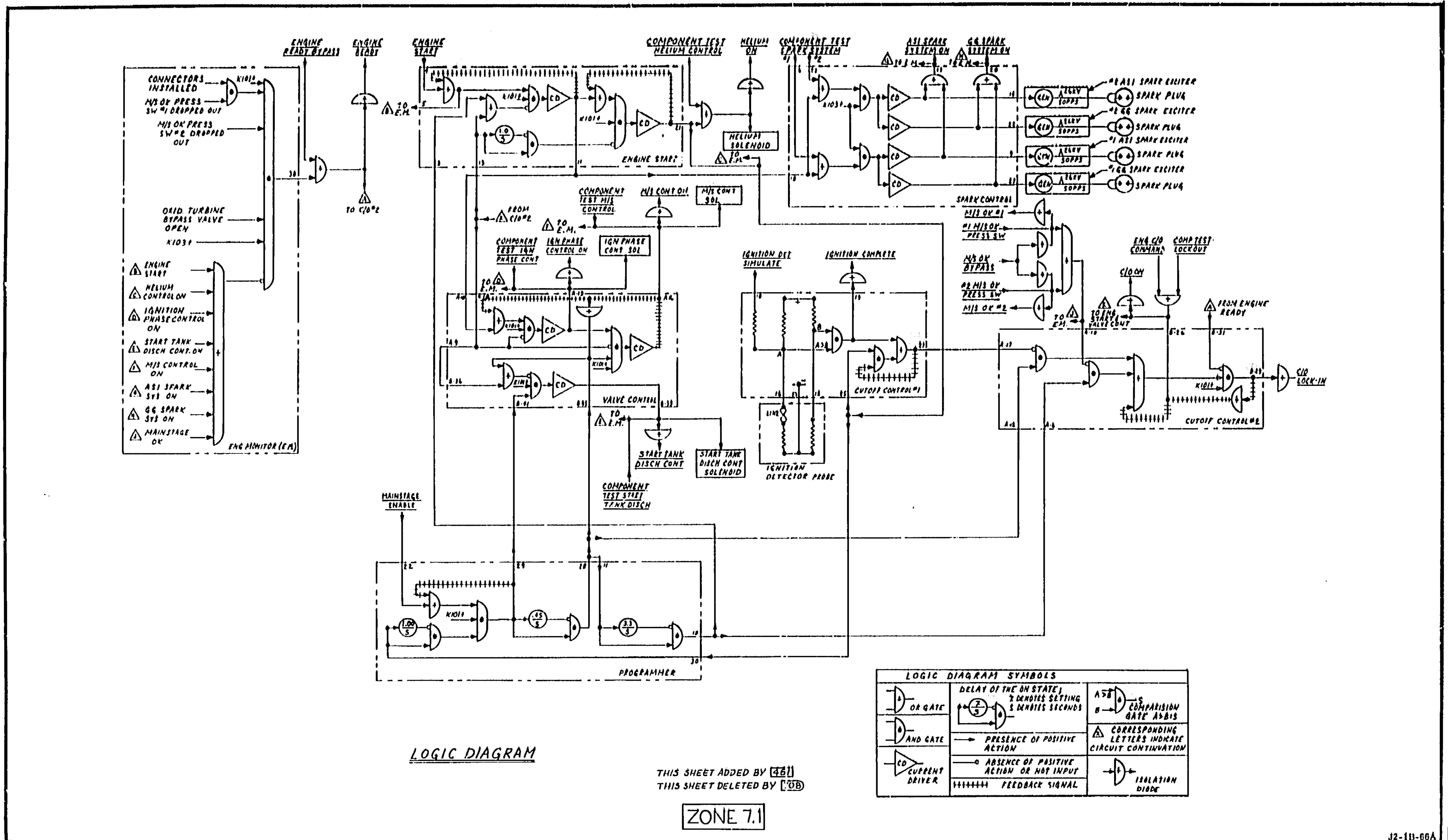


Figure 3-72. Engine Electrical Schematic (Sheet 8 of 24)

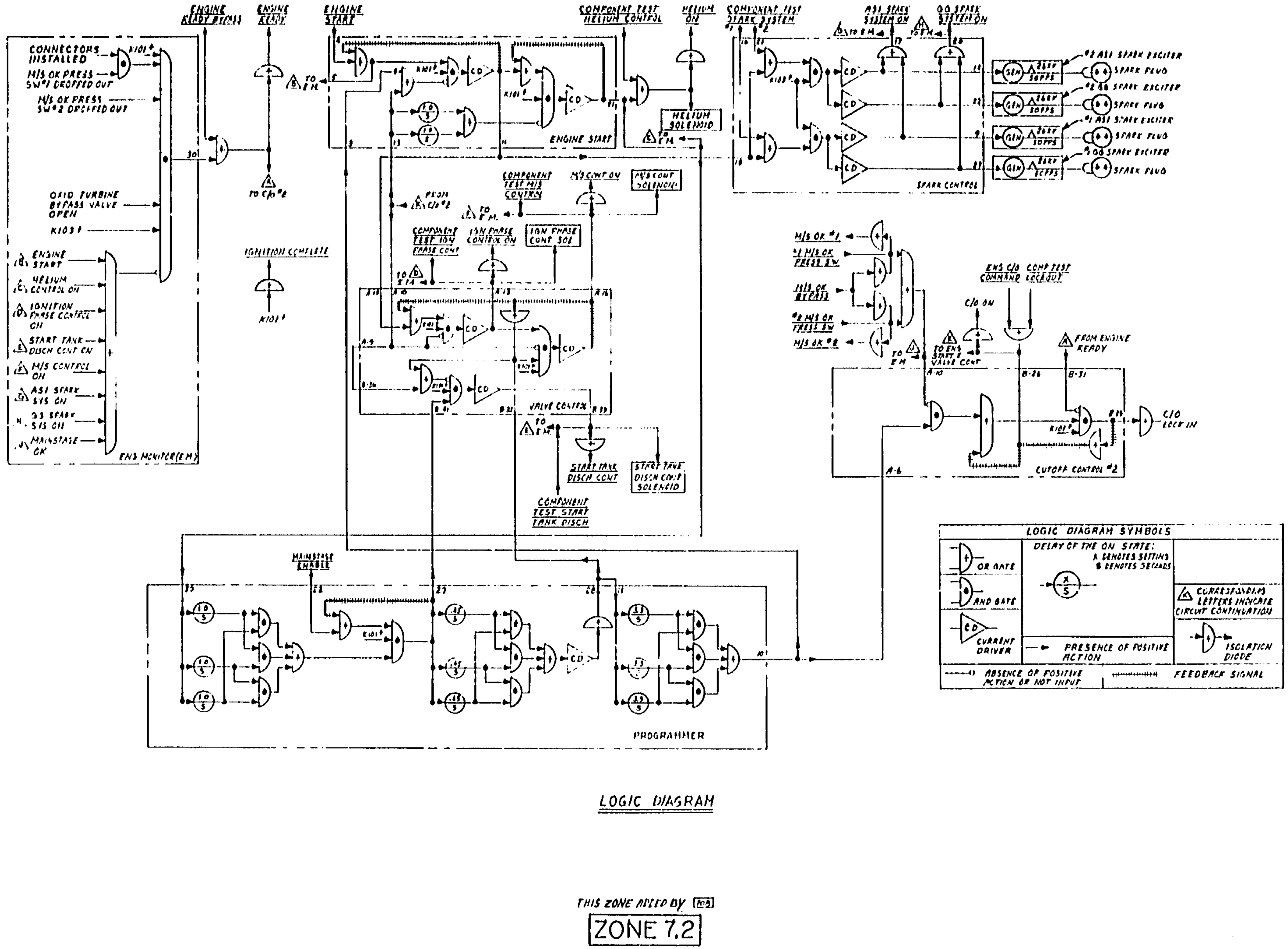


Figure 3-72. Engine Electrical Schematic (Sheet 8A of 24)

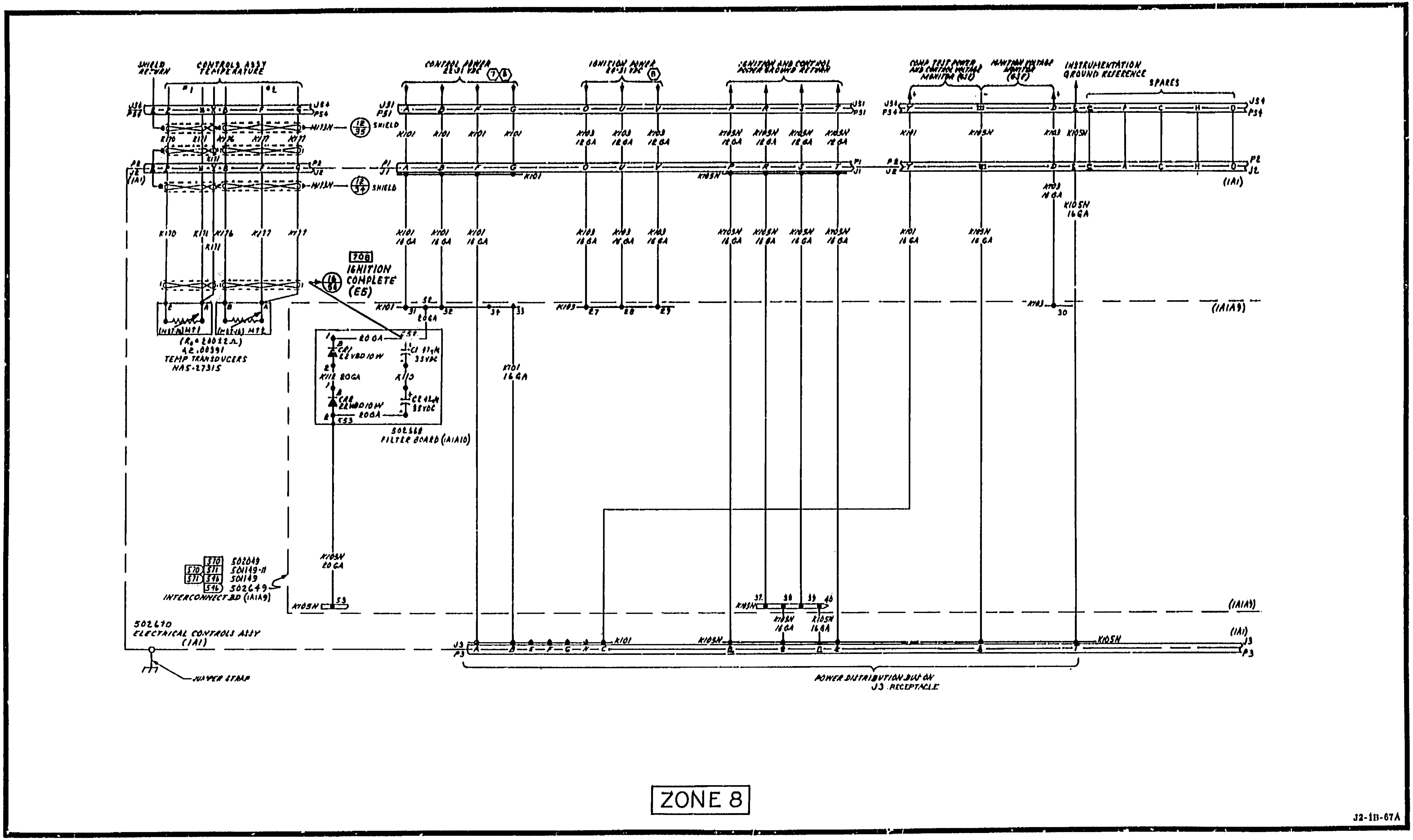


Figure 3-72. Engine Electrical Schematic (Sheet 9 of 24)

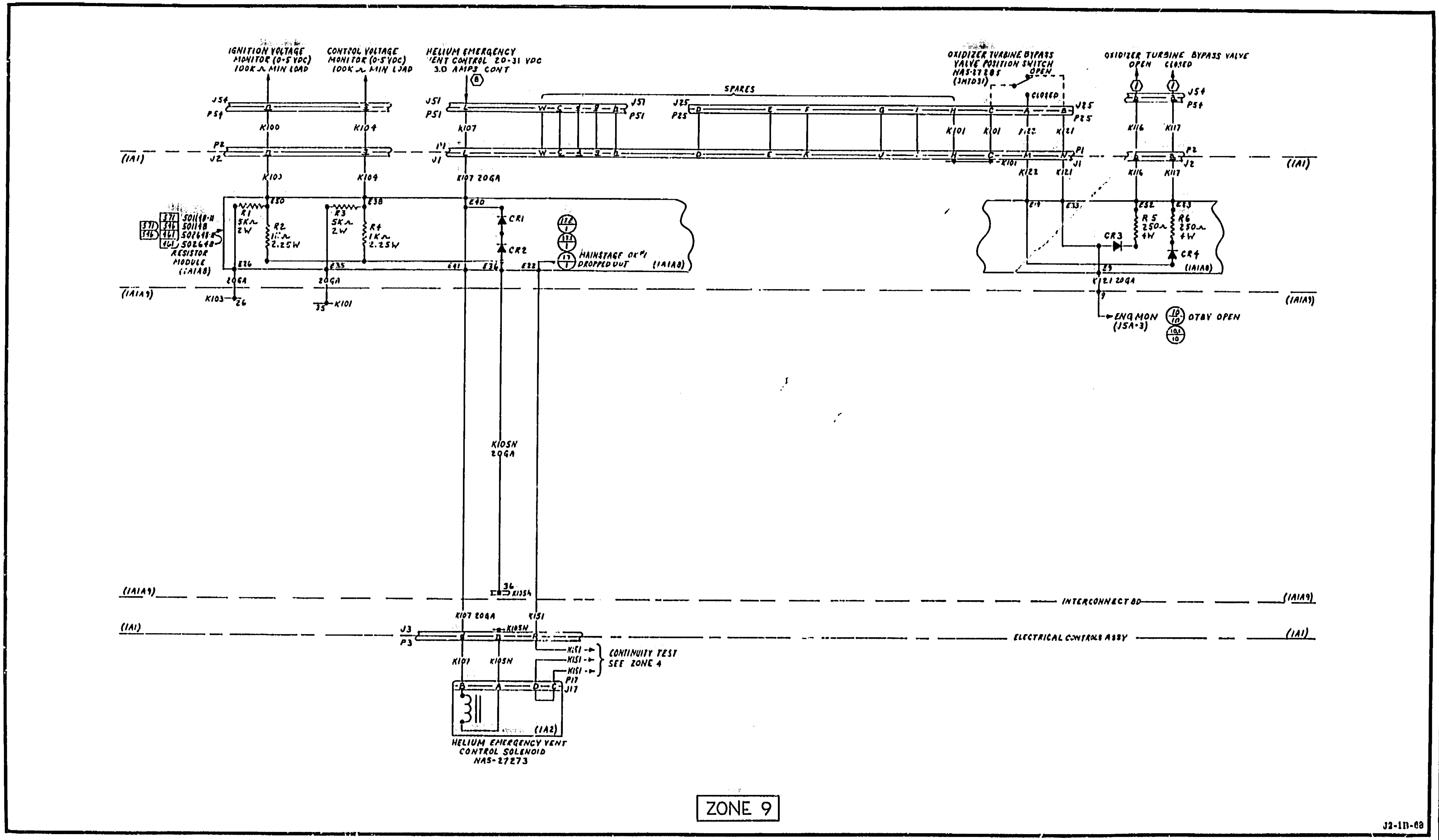


Figure 3-72. Engine Electrical Schematic (Sheet 10 of 24)

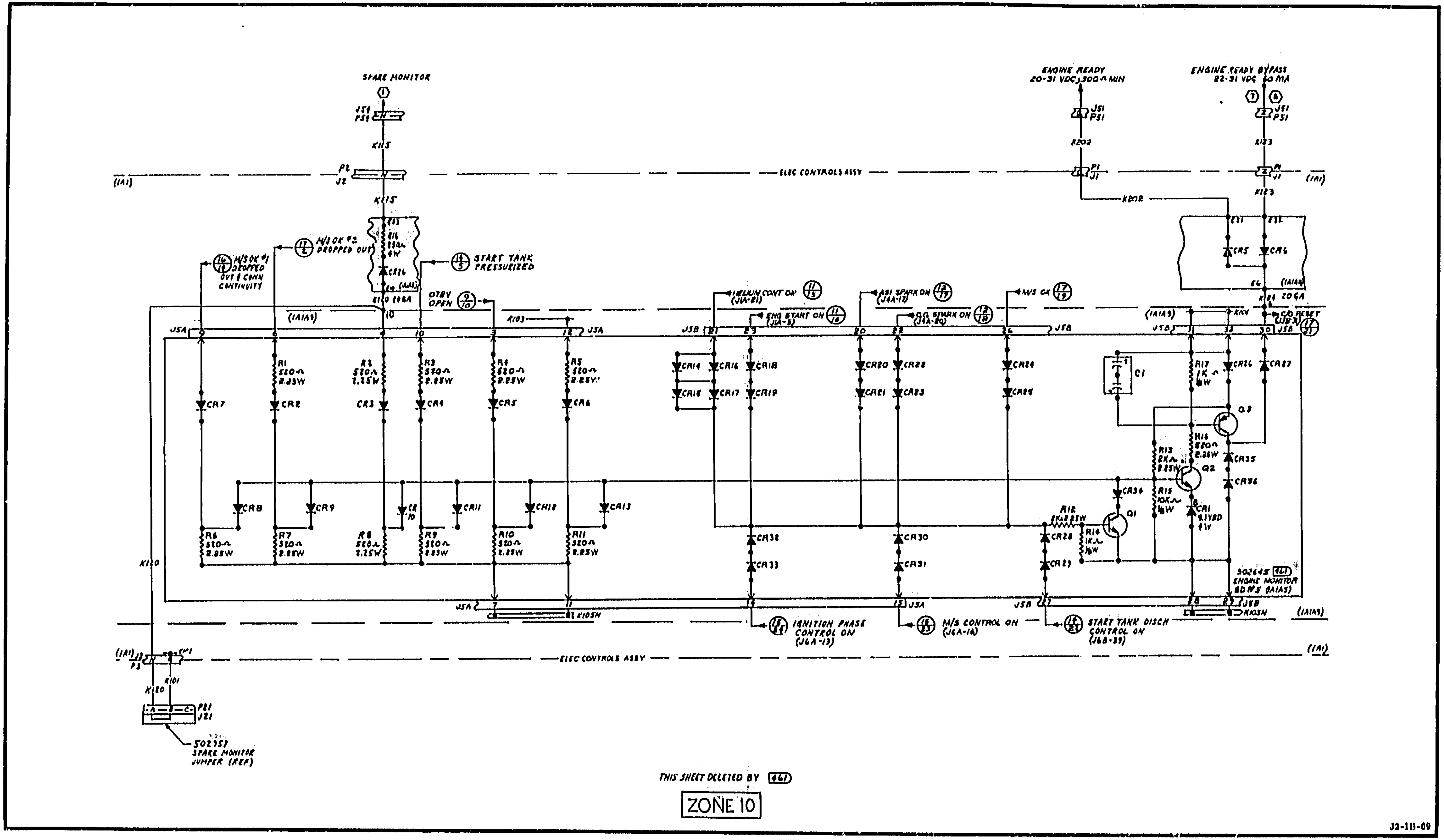


Figure 3-72. Engine Electrical Schematic (Sheet 11 of 24)

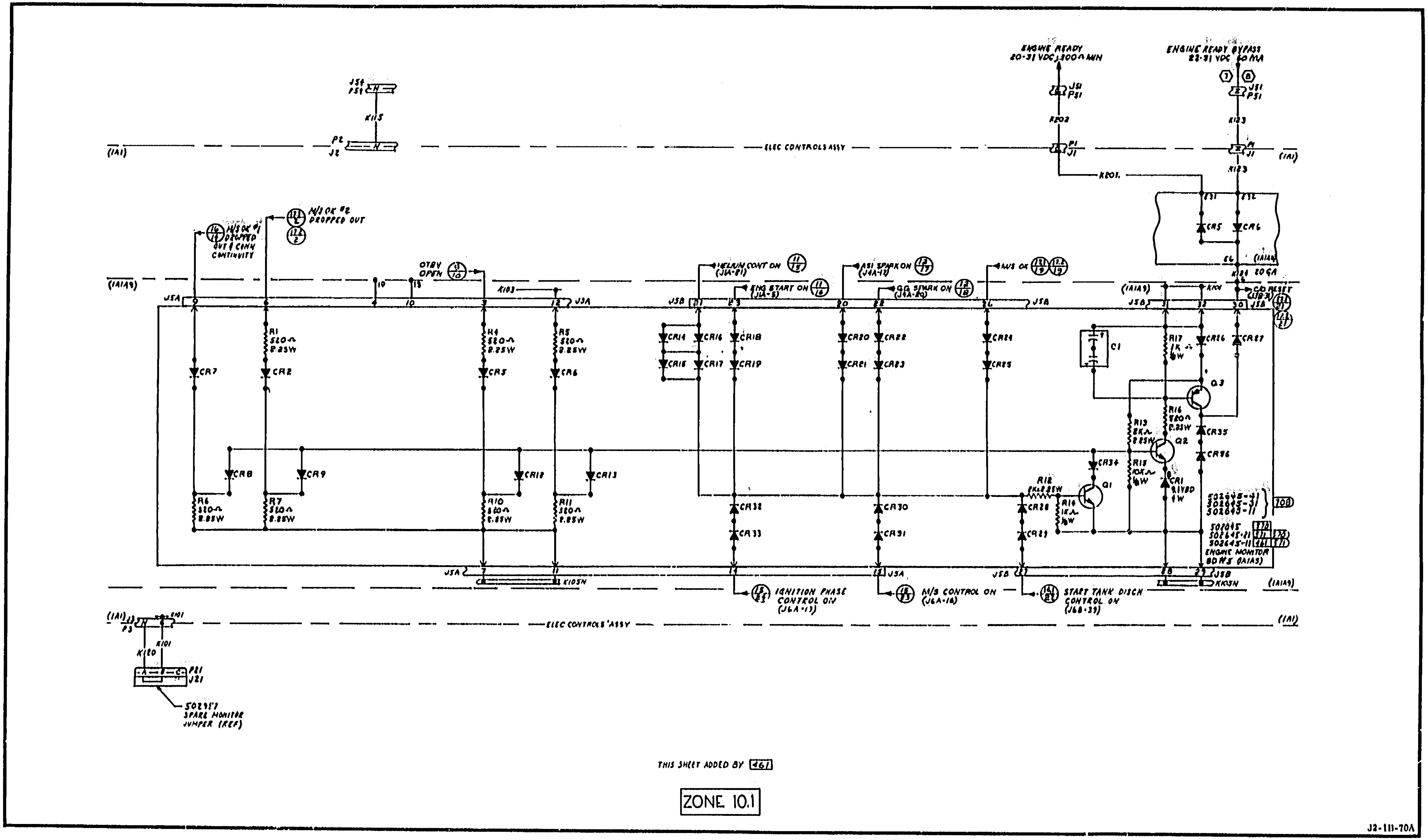


Figure 3-72. Engine Electrical Schematic (Sheet 12 of 24)

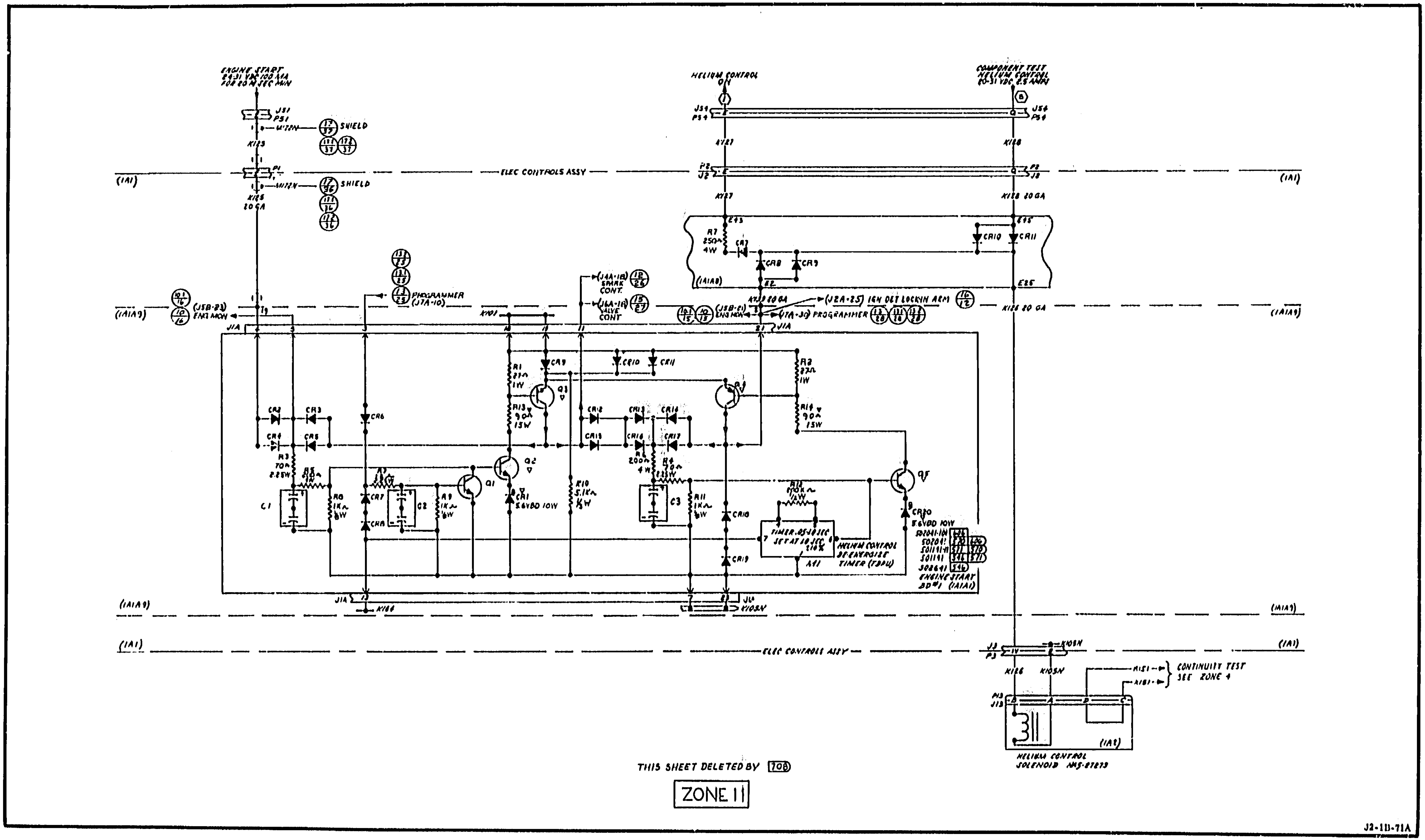


Figure 3-72. Engine Electrical Schematic (Sheet 13 of 24)

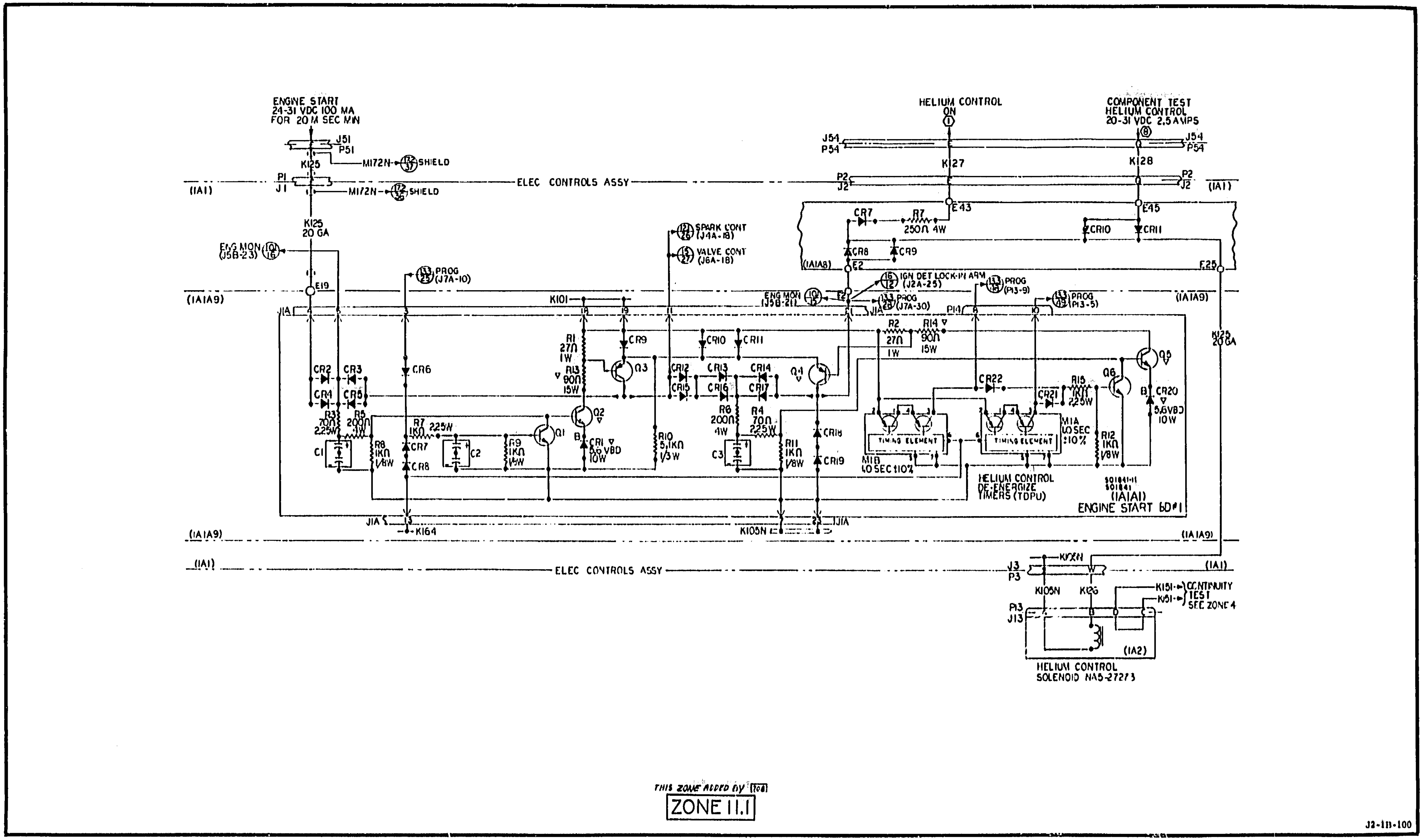


Figure 3-72. Engine Electrical Schematic (Sheet 13A of 24)

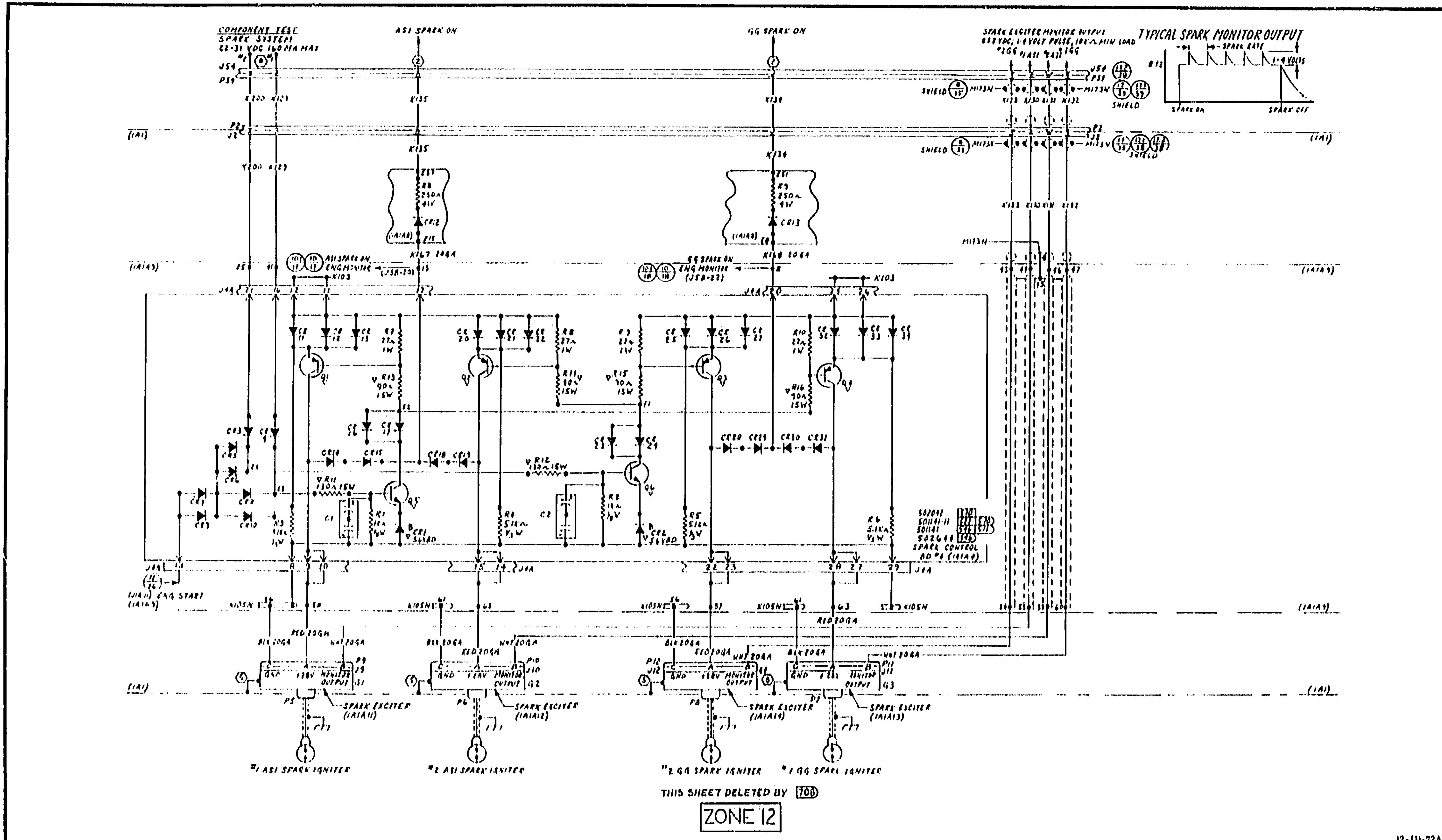


Figure 3-72. Engine Electrical Schematic (Sheet 14 of 24)

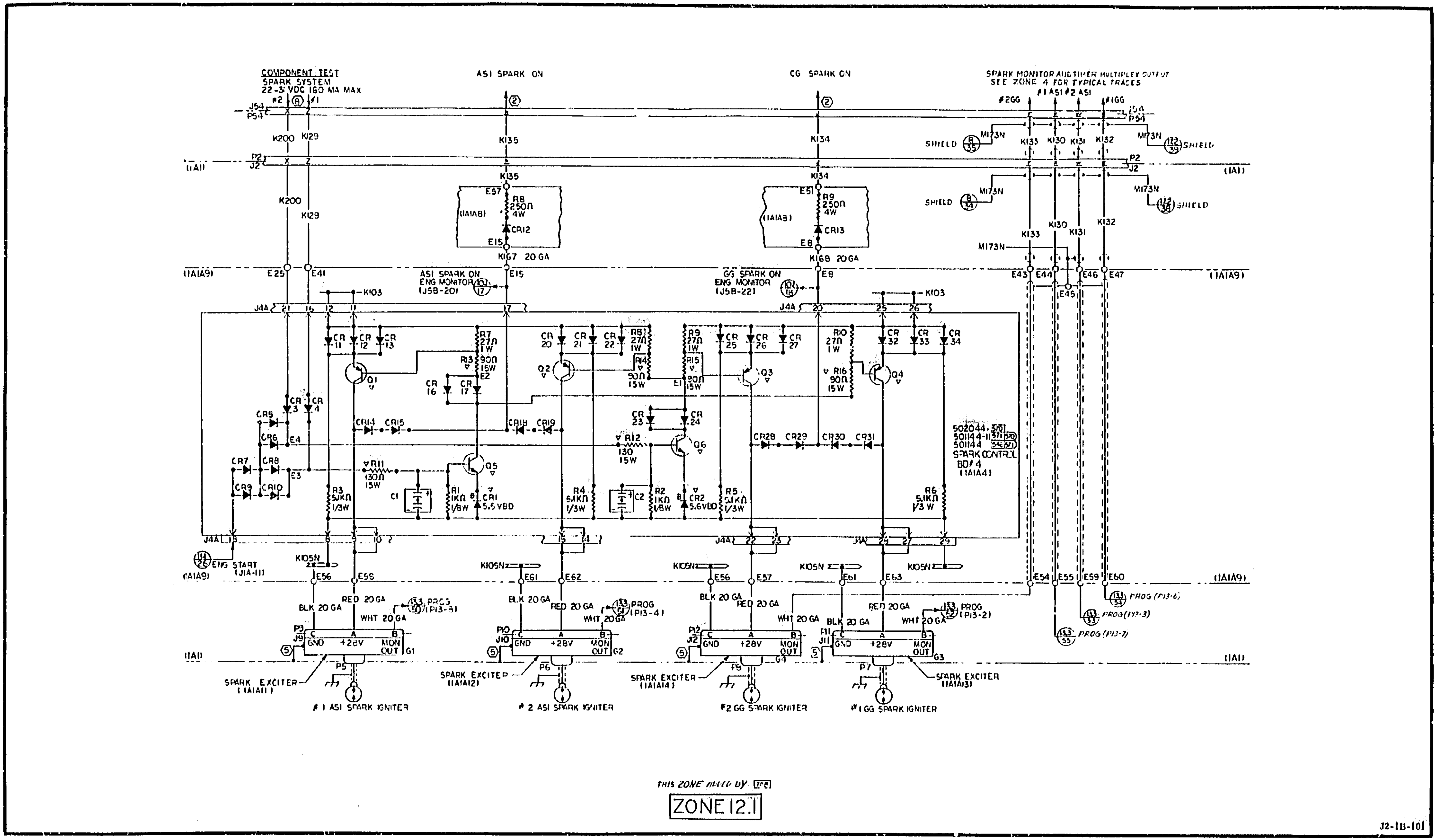


Figure 3-72. Engine Electrical Schematic (Sheet 14A of 24)

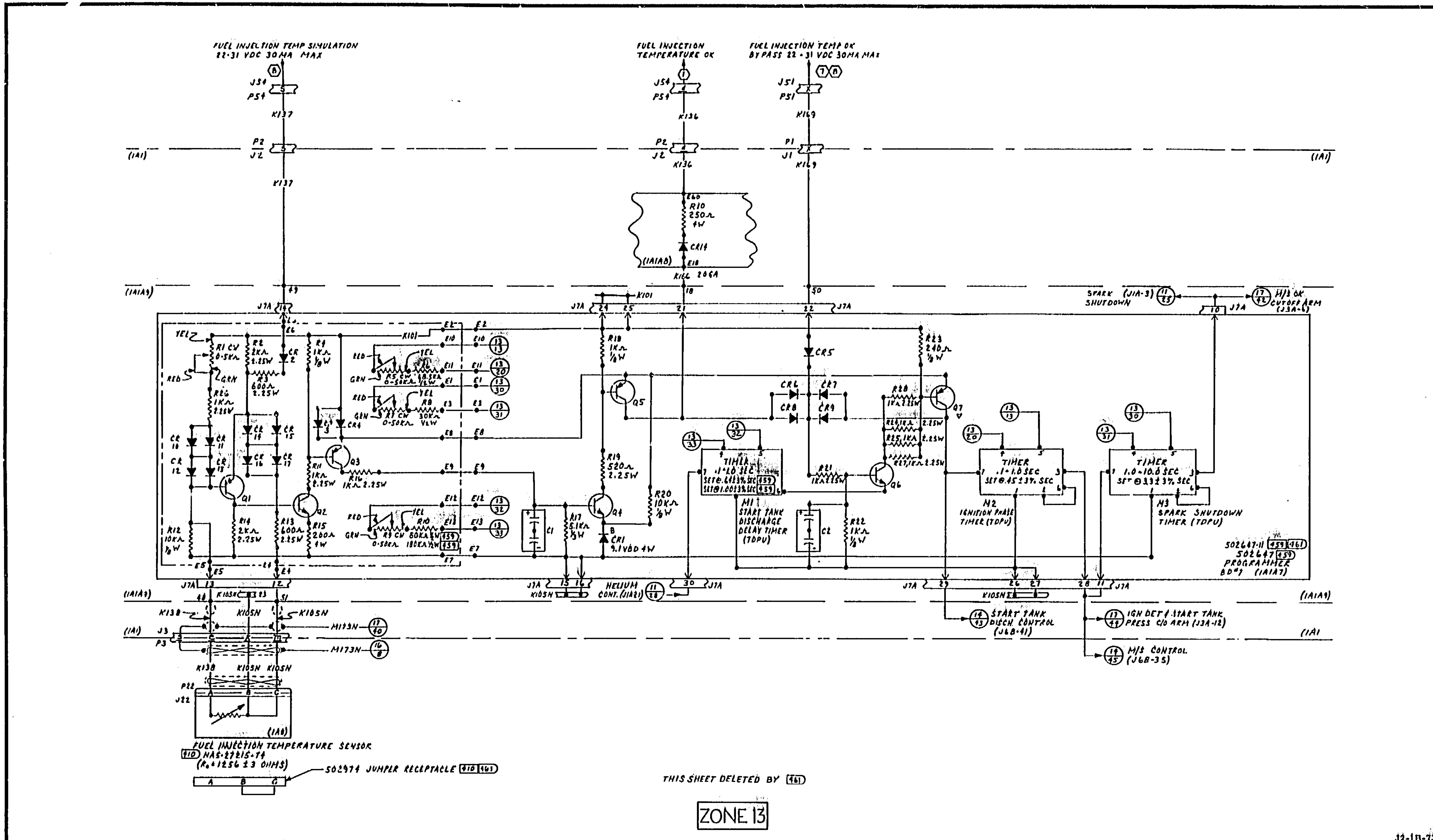


Figure 3-72. Engine Electrical Schematic (Sheet 15 of 24)

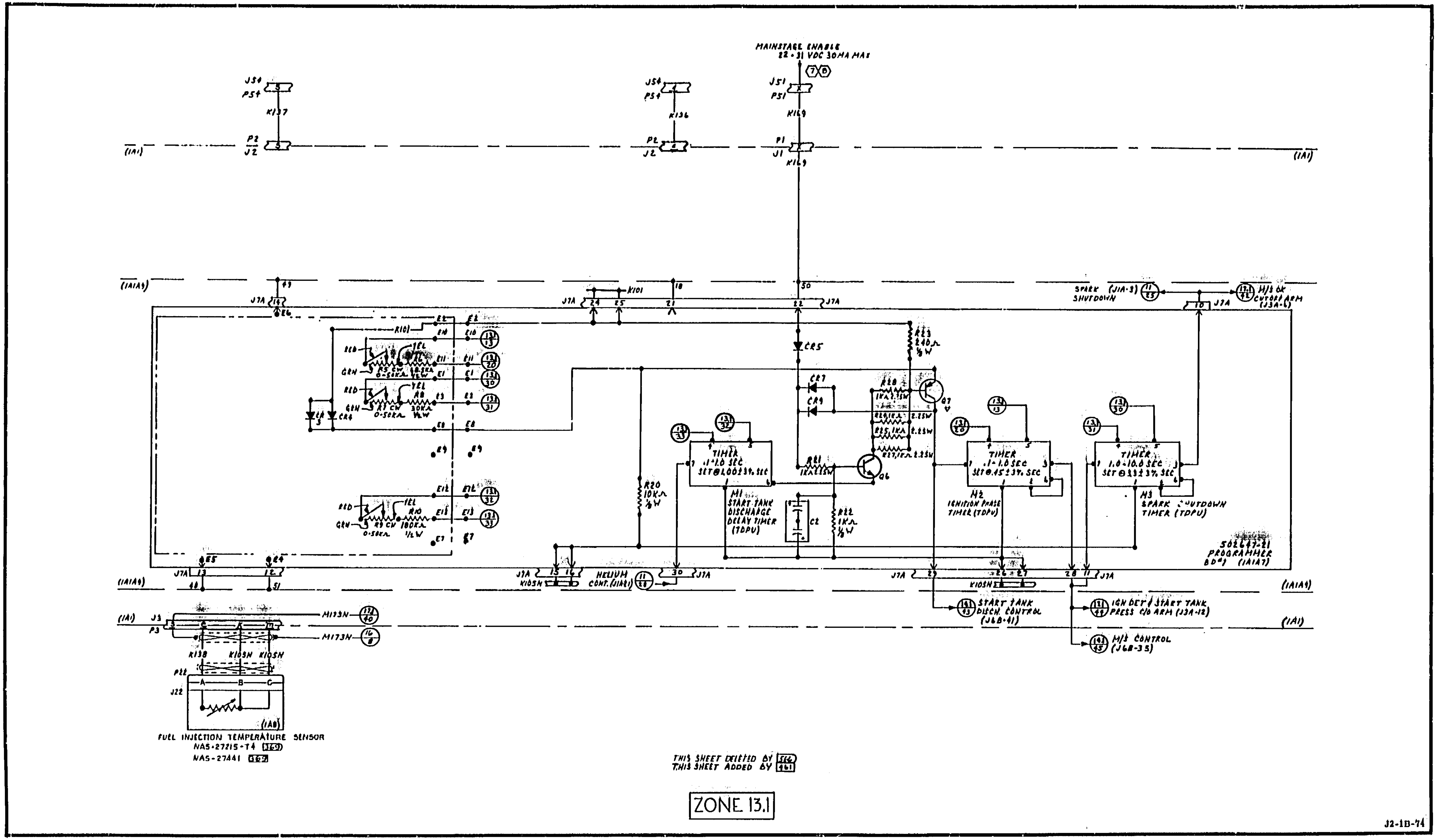


Figure 3-72. Engine Electrical Schematic (Sheet 16 of 24)

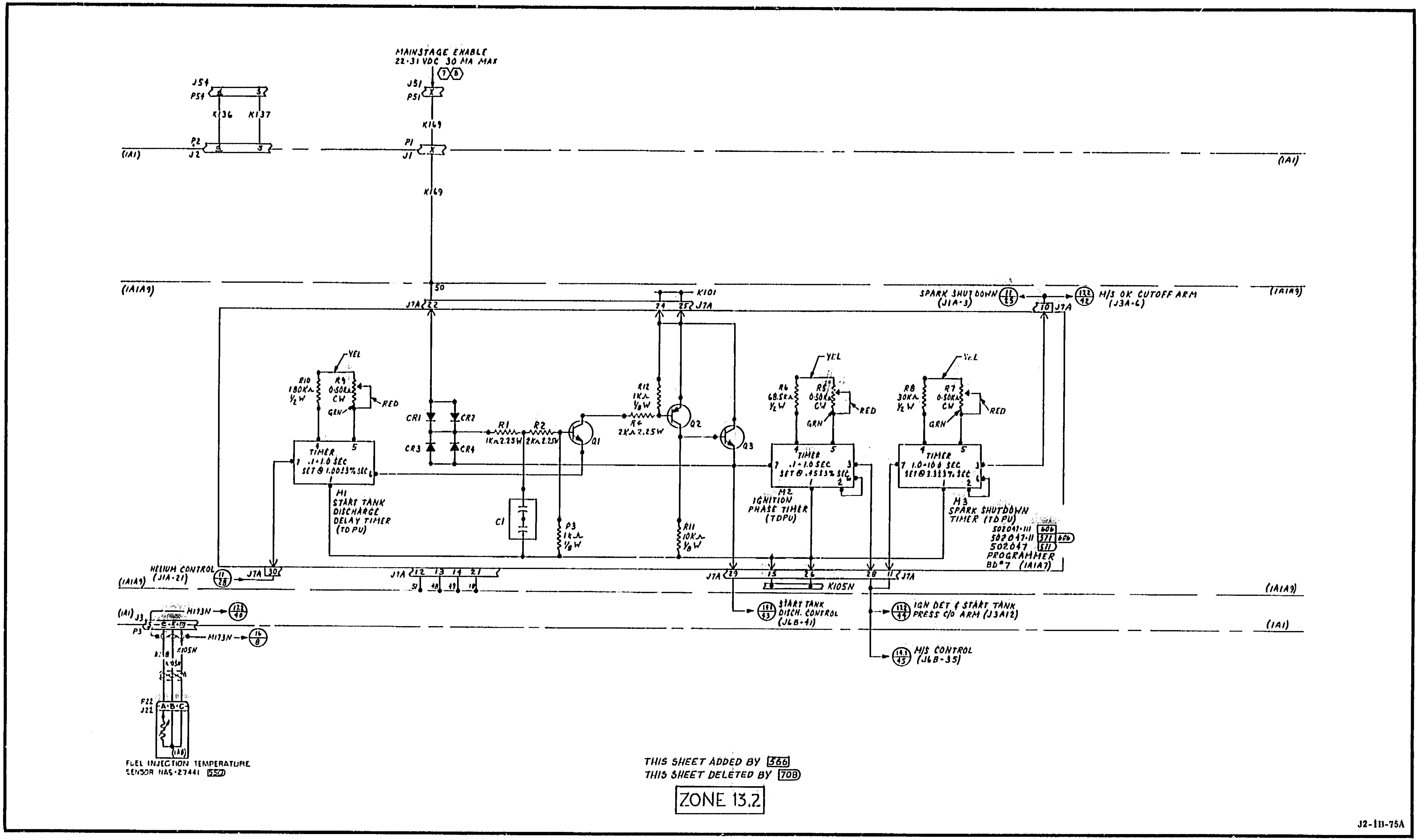


Figure 3-72. Engine Electrical Schematic (Sheet 17 of 24)

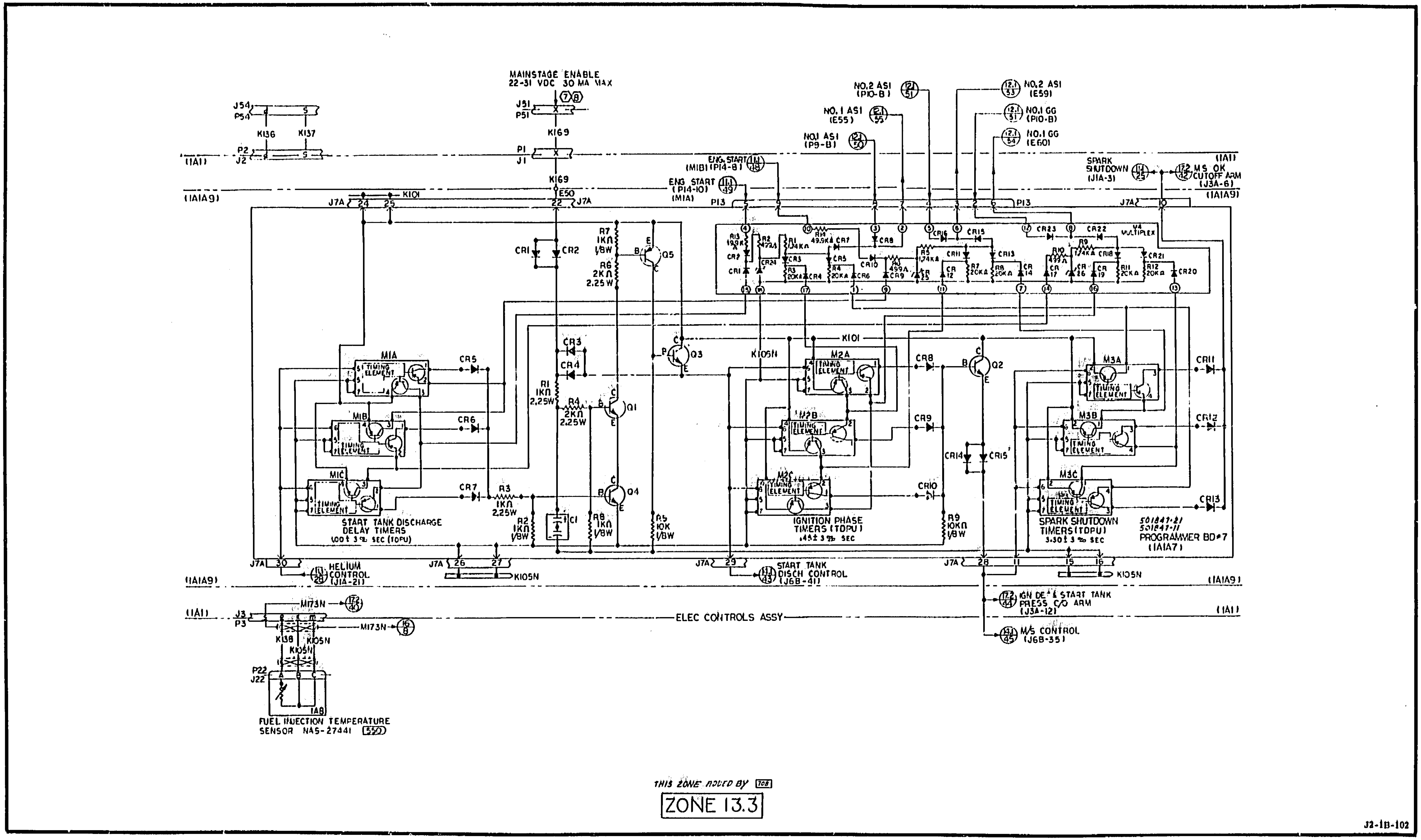


Figure 3-72. Engine Electrical Schematic (Sheet 17A of 24)

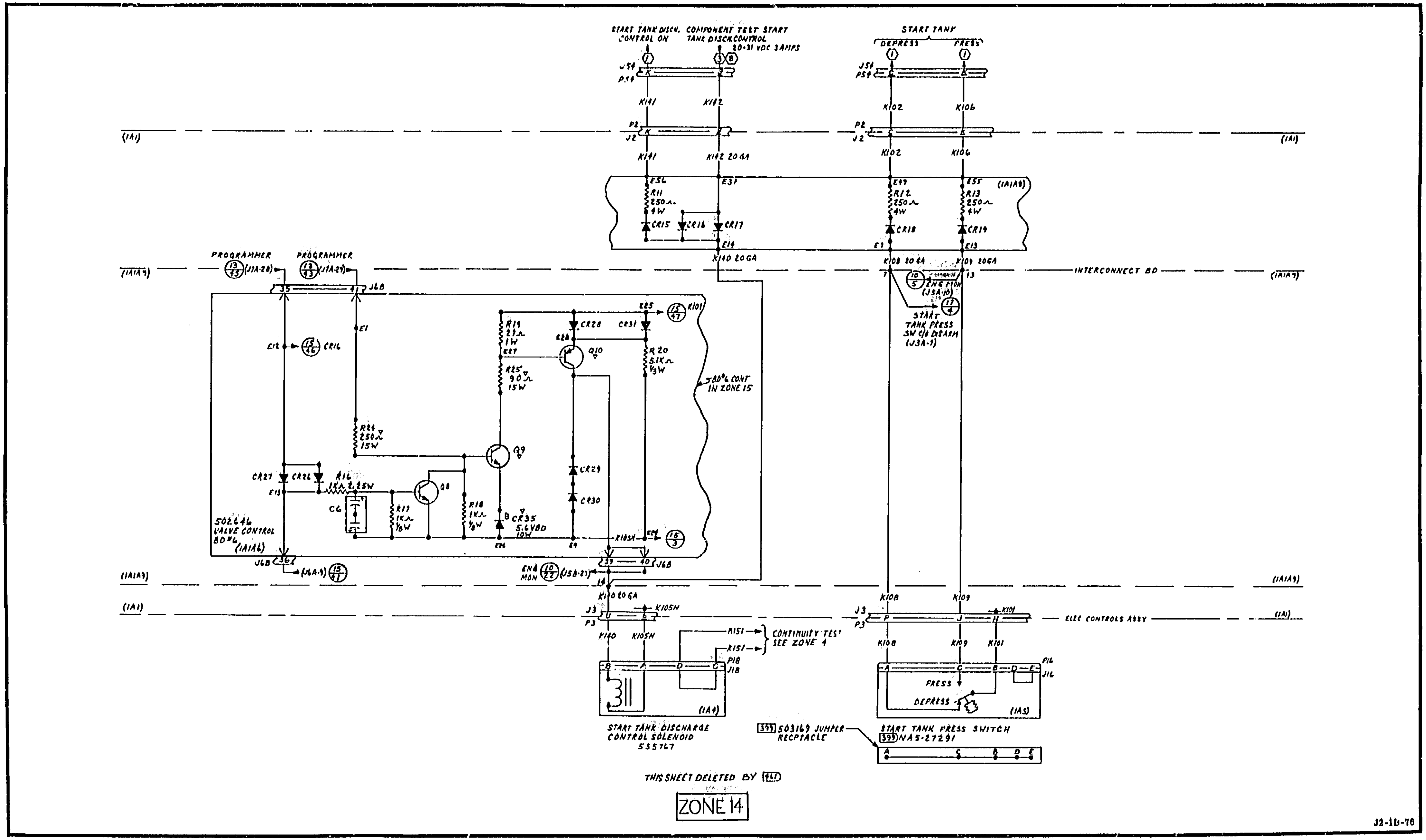


Figure 3-72. Engine Electrical Schematic (Sheet 18 of 24)

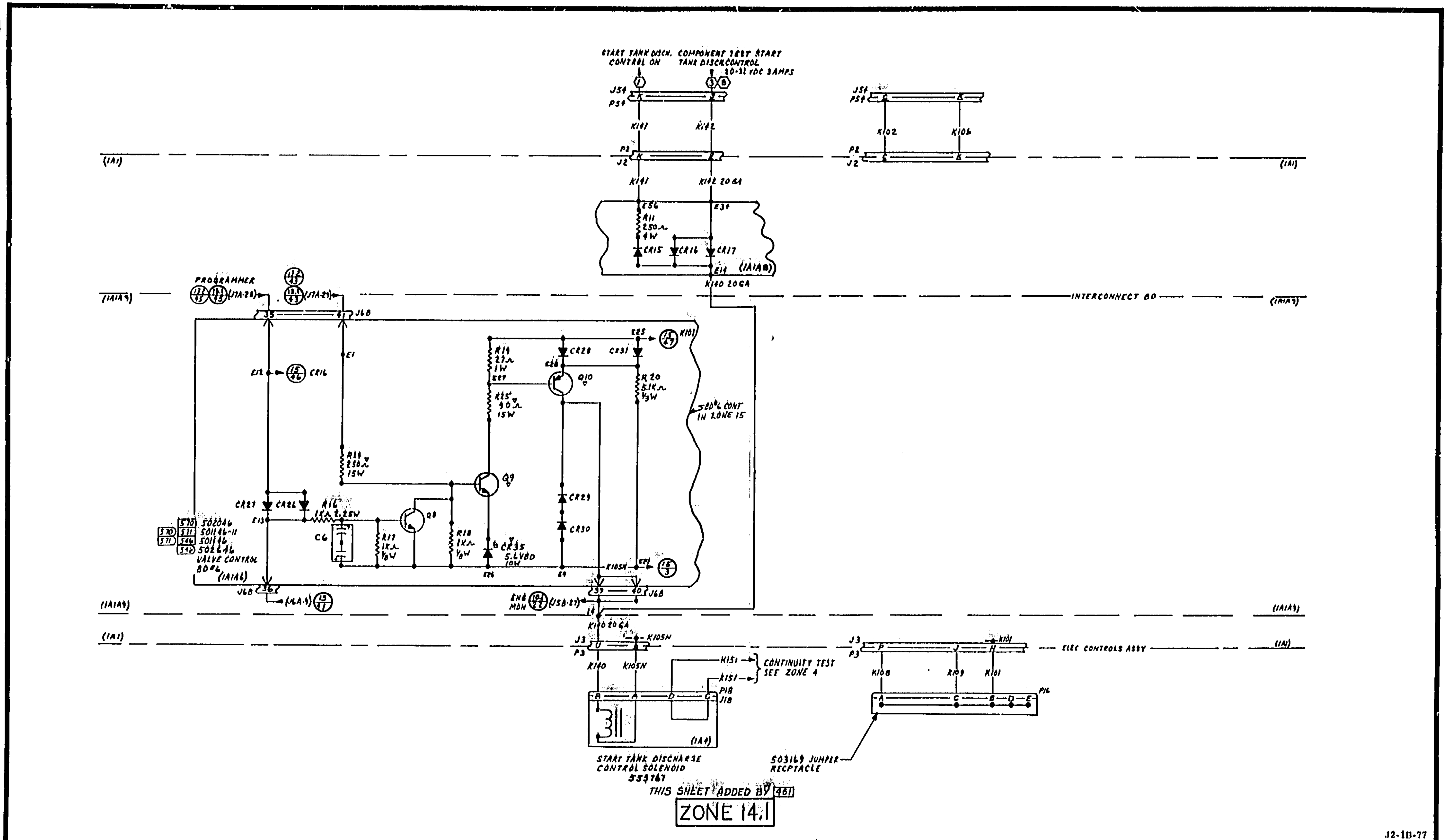


Figure 3-72. Engine Electrical Schematic (Sheet 19 of 24)

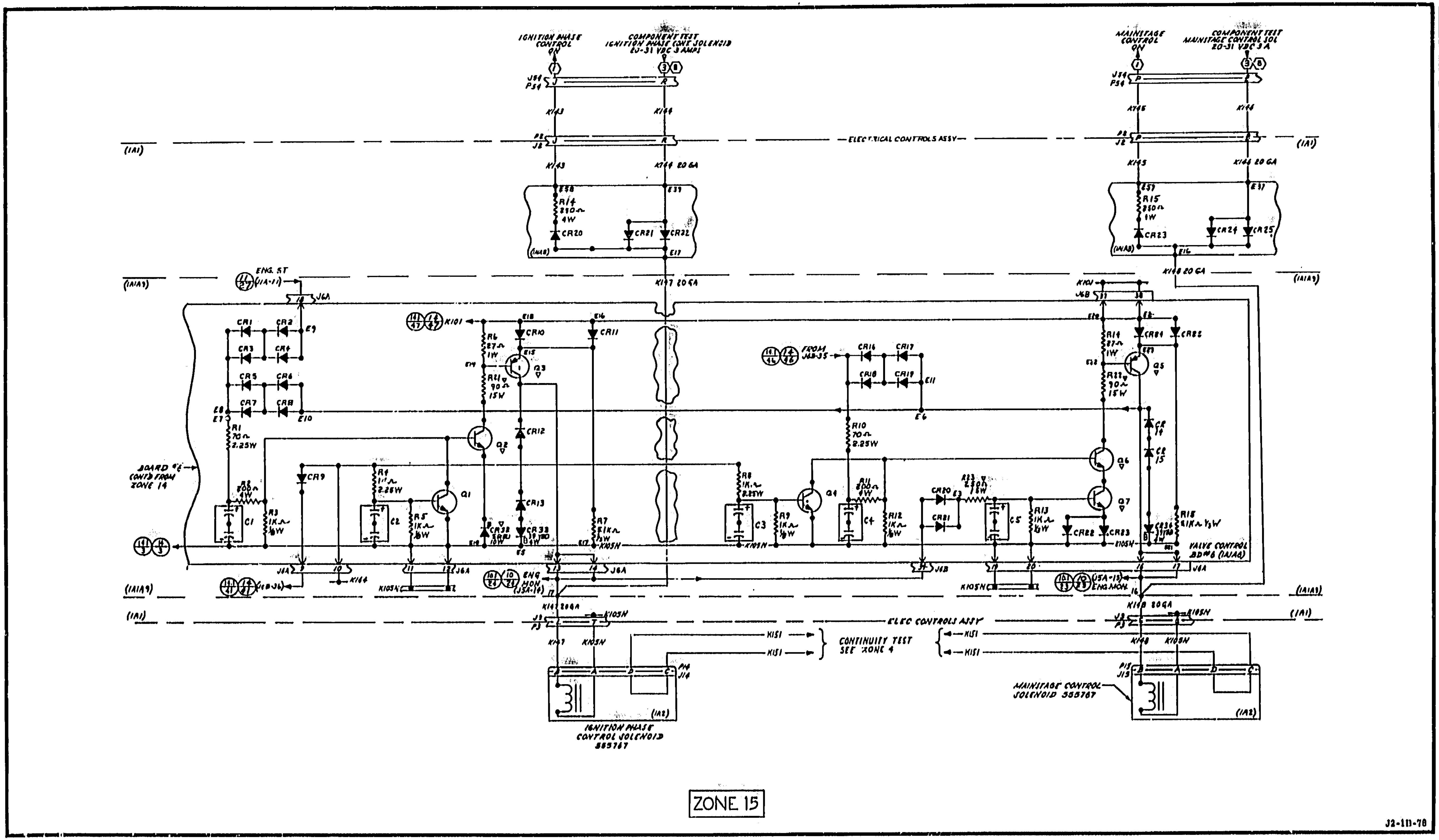


Figure 3-72. Engine Electrical Schematic (Sheet 20 of 24)

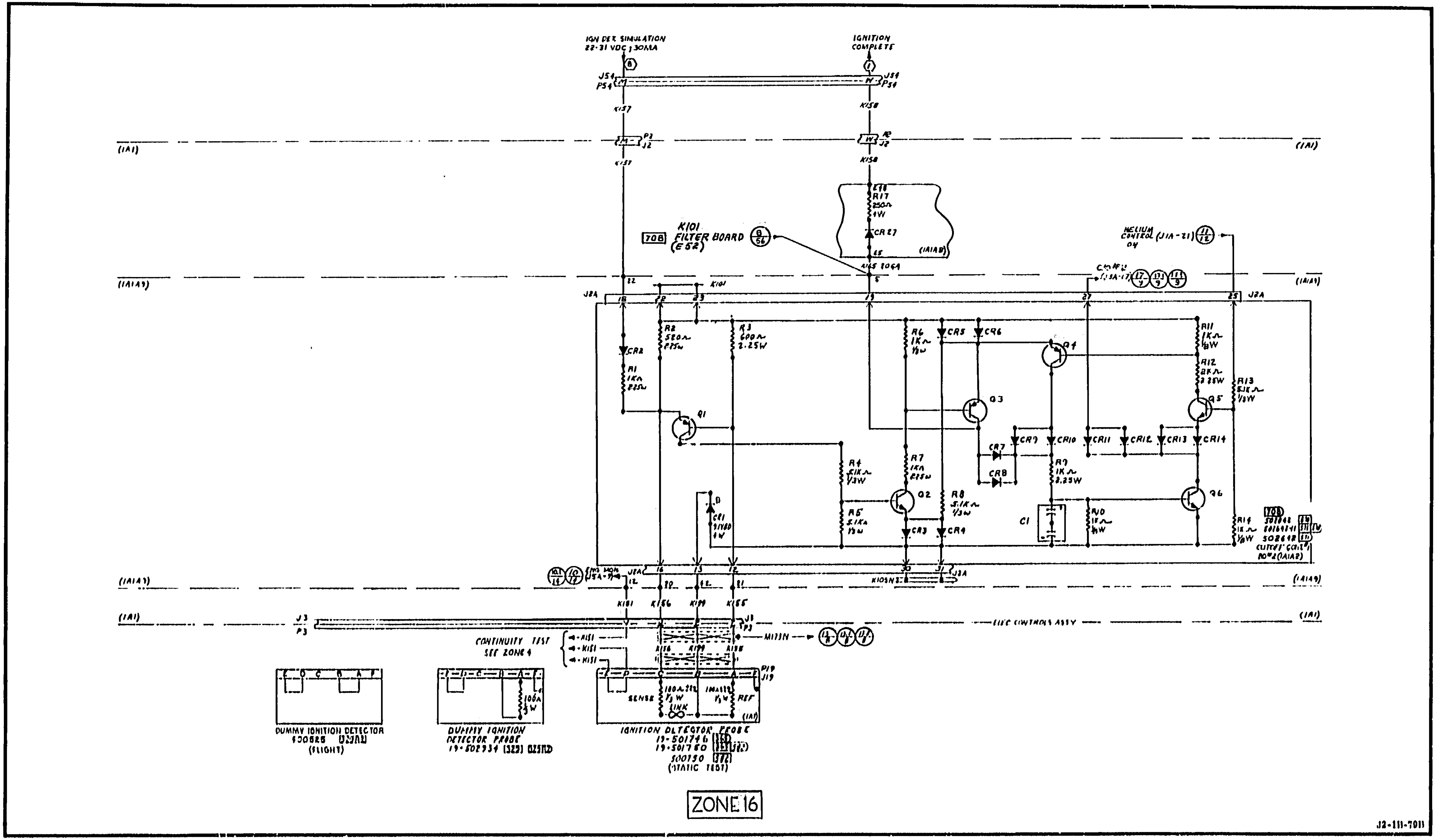


Figure 3-72. Engine Electrical Schematic (Sheet 21 of 24)

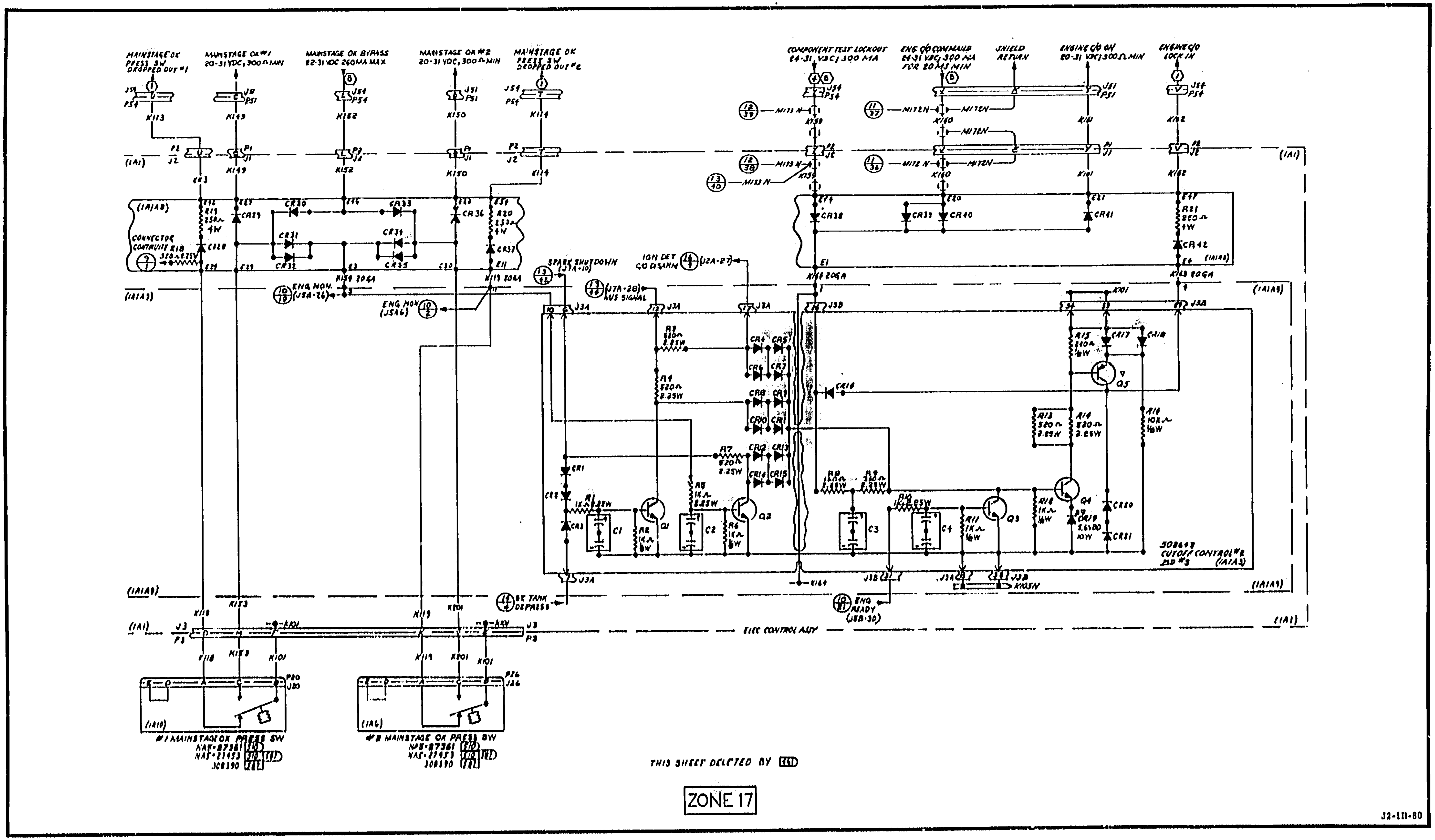


Figure 3-72. Engine Electrical Schematic (Sheet 22 of 24)

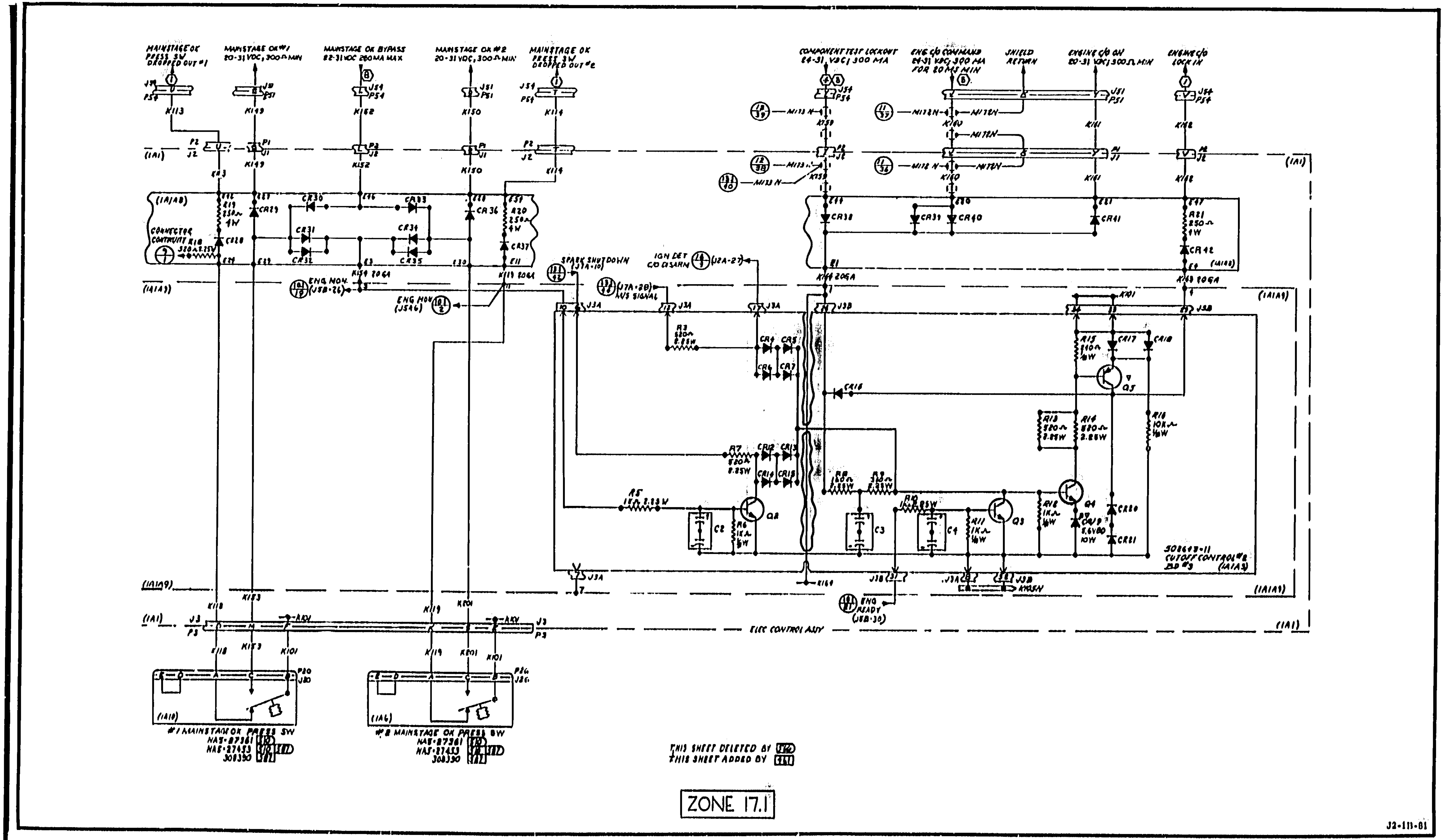


Figure 3-72. Engine Electrical Schematic (Sheet 23 of 24)

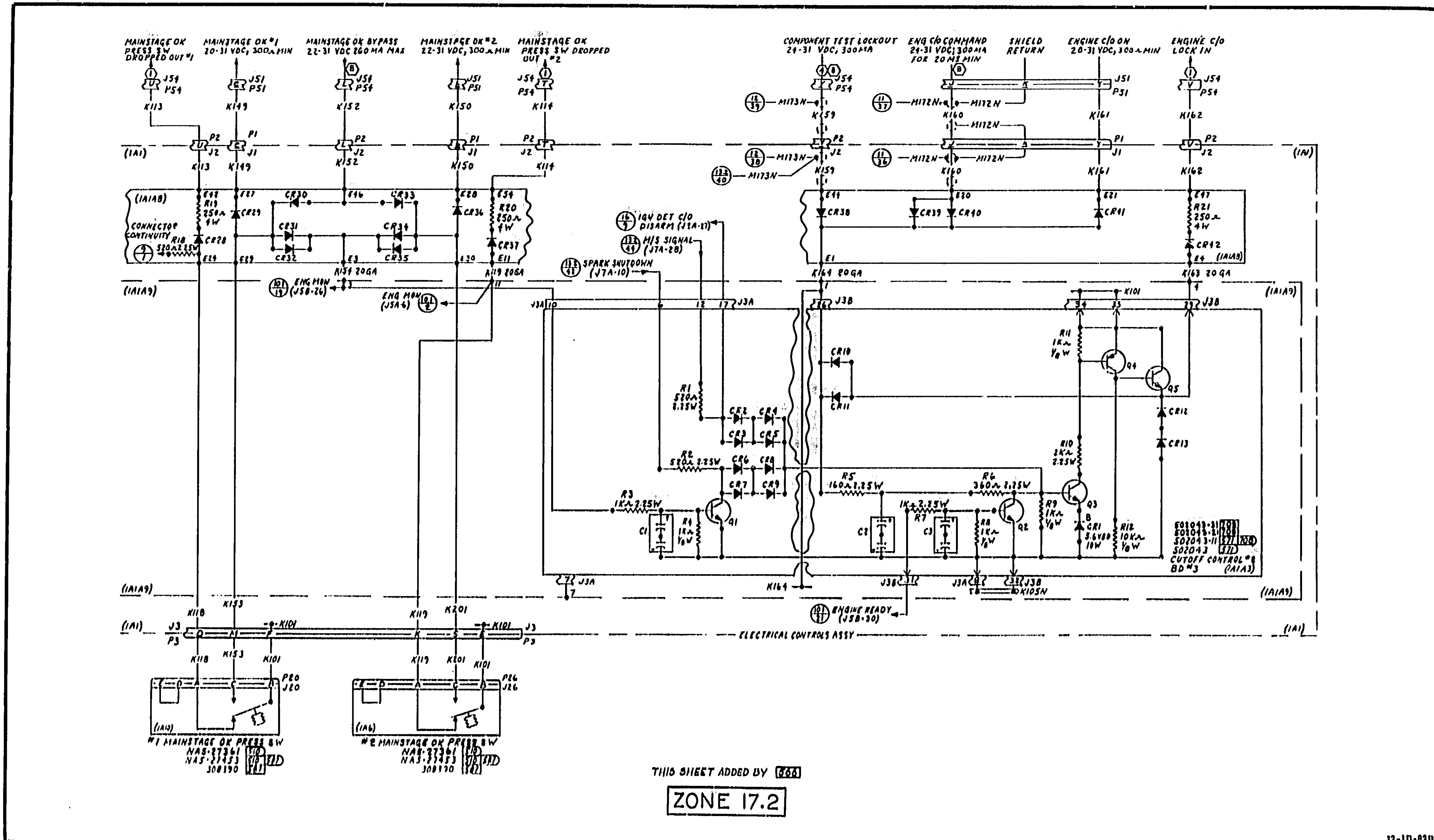


Figure 3-72. Engine Electrical Schematic (Sheet 24 of 24)

3.8 MAINTAINING ENGINE LOG BOOK.

3.8.1 PURPOSE. The following paragraphs contain the general requirements and instructions necessary to make entries of standard accuracy and completeness in the log book delivered with the engine. The Engine Log Book is the official document for recording the operational status and configuration of the engine from production to launch.

3.8.2 SOURCE DOCUMENTATION. To assist in the maintenance of the Engine Log Books, the entries required for a task are specified in engine Modification Instructions, and Engine Field Inspection Requests (EFIRs) that support technical manual instructions. Modification Instructions and EFIRs include necessary instructional steps and an attachment for log book data transmittal to organizations having log book maintenance responsibility.

3.8.3 WHEN TO UPDATE LOG BOOK. Log books must reflect open as well as completed tasks or events, and initial entries should be made as soon as requirements are identified or approval documents received. The log book must be reviewed and updated at least each time any of the following tasks or events is completed: (Rocketdyne Configuration Report R-5788 may be used to verify open log book entries for modification and Engine Field Inspection Request (EFIR) tasks.)

a. Engine Contractor receiving inspection.

b. Stage Contractor receiving inspection.

c. Engine post-modification checkout.

d. Vehicle post-manufacturing checkout.

e. Storage.

f. Preparation for shipment.

g. Pre-static firing modification and checkout.

h. Prelaunch.

3.8.4 HOW TO UPDATE LOG BOOK. Log book entries should be typewritten. Entries handprinted in ink are acceptable when typewritten entries are impractical. (Additional general rules are outlined in paragraphs 3.8.4.1 through 3.8.4.10.)

3.8.4.1 Abbreviations. Abbreviations to be used in the preparation and maintenance of the Engine Log Book are listed in the introductory data of the individual log books or are defined in this manual. The abbreviation UNK or DNA must be inserted in blank spaces for which information is unknown or does not apply.

3.8.4.2 Definition of Terms. The terms to be used in preparation and maintenance of the Engine Log Book are listed in the introductory data of the individual log books or are defined in the detailed instructions in this manual.

3.8.4.3 Identifying Vehicle, Organization, and Location. The symbols used in preparation and maintenance of the Engine Log Book, to identify the vehicles, sites (locations), and organizations must be consistent with the following:

a. Vehicles:

(1) Saturn I: Second stage, S-IVB-2XX.

(2) Saturn V:

(a) Second stage, S-II-X.

(b) Third stage, S-IVB-5XX.

b. Organization locations:

(1) Rocketdyne, Kennedy Space Center, RD-KSC.

(2) Rocketdyne, Marshall Space Flight Center, RD-MSFC.

(3) Rocketdyne, Mississippi Test Facility, RD-MTF.

(4) Rocketdyne, Seal Beach, RD-SB.

(5) Rocketdyne, Huntington Beach, RD-HB.

(6) Rocketdyne, Sacramento, RD-STC.

(7) Rocketdyne, Tullahoma, RD-AEDC.

3.8.4.4 Entering Dates. All dates entered in the log book must be recorded by the day, month (abbreviated), and year (for example, 10 Mar 68).

3.8.4.5 Rounding-Off Parameter Values. All recorded parameter values must be rounded off to the desired number of significant figures by rounding up whenever the digit next to the last desired significant figure is 5 or greater and rounding down whenever the digit next to the last desired significant figure is less than 5.

3.8.4.6 Verifying Log Book Entries (Log Book Audit). Engine Log Books must be reviewed at least concurrent with each receiving inspection and before shipping and launch, to ensure that the books are complete and accurate. Log Book audits will be documented on the Transfer Record-Engine History form of the log book. Government inspection signoff is required for these entries. (Rocketdyne Configuration Report R-5788 may be used to verify open log book entries for modification and Engine Field Inspection Request (EFIR) tasks.)

3.8.4.7 Deleting Log Book Entries Made in Error. Erasures are not permitted. If an error is made, the incorrect entry must be voided and the abbreviation EIE (entered in error) entered adjacent to the line. The initials or stamp of the individual who made the entry must be entered adjacent to the entry.

3.8.4.8 Voiding Obsolete Log Book Entries. Erasures are not permitted. With a single inked line, line-out the obsolete entry; do not obliterate the entry. The initials or stamp of the individual voiding the entry must be entered adjacent to the line.

3.8.4.9 Inserting Additional or New Log Book Forms. Additional copies of the same form must be used in the event a single form does not provide enough space for recording all of the required information. These forms must be added to the log book immediately behind the form affected. All new or additional forms must have the engine model and serial number entered on the form before insertion in the log book. New log book forms, when applicable, must be inserted in accordance with the detailed instructions in paragraph 3.8.6.

3.8.4.10 Entering Inspection Signatures or Stamps. The individual making a data entry in the Engine Log Book must also enter his signature or stamp in the inspection signoff column of the log book form. Unless otherwise specified in the detailed instructions, the signature or stamp is a verification of the accuracy and completeness of the entry as transcribed from the source data and does not indicate verification of the completion or observance of a specific task.

NOTE

Government inspection signoff of entries on specified forms is not required except when a log book audit is performed.

3.8.5 TRANSFERRING LOG BOOK. The Engine Log Book must accompany the engine whenever custody is transferred or the engine is shipped. The organization having custody of the engine is responsible for transferring the log book.

3.8.6 LOG BOOK FORMS THAT REQUIRE POST-DELIVERY MAINTENANCE. The J-2 Engine Log Book consists of introductory matter and 9 or 10 major sections containing engine records and forms. Instructions for completing log book form entries, corrections, and transfers are presented for those forms that may require post-delivery maintenance; these forms are:

- Engine Identification
- Transfer Record section
  - Transfer Record--Engine History
- Acceptance Data Log section
  - Engine Weight Record
- Component Calibration Data section
  - Instrumentation Road Maps
- Checkout Data section
  - Sequence Timing Record[a]
  - Flight Instrumentation Checkout[a]
  - Leakage, Flow, and Turbopump Torque Tests[a]
  - Checkout Notes and Comments[a]
- Operational Data Log section
  - Operational Data, Engine Performance Summary

(a) This form is not in all log books as delivered but must be inserted after engine delivery.

Operational Data, Gimbal Test Record

J-2 Start Tank Pressure Cycle Life Work Sheet[a]

Helium Regulator Assembly Operation Record[a]

Engine Test Record section

Engine Test Record

Configuration Record section

Configuration Record

Serialized Component Record section

Delivered Serialized Component Record[b]

Post-Delivery Serialized Component Replacement Record

Orifice Record section

Delivered Orifice Record

Post-Delivery Orifice Replacement Record

Inspection Records section

Discrepancy Record

Age Control Log for Component Synthetic Rubber Items

Delivered-Engine Shortage Record

Spark Cable Pressurization Record[a]

ECA Pressurization Record[a]

Primary FI Package Pressurization Record[a]

Auxiliary FI Package Pressurization Record[a]

Inspection Record

Special Notes and Comments

(a) This form is not in all log books as delivered but must be inserted after engine delivery.

(b) This form is not in all log books. Engine Serialized Parts Record is in earlier log books. The purpose of the two forms is identical.

3.8.7 HOW TO DETERMINE LOG BOOK ENTRY REQUIREMENTS. The Minimum Log Book Entry Requirements chart (figure 3-73) identifies which log book forms must be updated when specific tasks are performed or events occur. Figure 3-73 reflects minimum requirements; additional log book forms (not listed in figure 3-73) may be affected depending on the nature or results of the task or event. Figures 3-74 through 3-96 specify when or under what conditions the additional forms will be affected. To determine the necessary log book entries for a specific task or event, proceed as follows: (See figure 3-73.)

a. Select the title that best describes the task or event. Example: An engine modification is to be performed in accordance with an approved Rocketdyne Engineering Change Proposal (ECP); the task title in figure 3-73 is Modification.

b. Search across the page to locate the figure number of the applicable instructions. This figure 3-85 provides general and detailed instructions for completing the log book form and makes reference to other log book forms that are (or may be) affected, depending on the nature and results of the task or event. The X's indicate the other forms that must be updated for that specific task or event.

Task or Event \ Log Book Form	Engine Identification	Transfer Record Engine History	Sequence Timing Record	Flight Instrumentation Record	Leakage, Flow, and Turbopump Torque Tests	Operational Data Engine Performance Summary	Operational Data Gimbal Test Record	Helium Regulator Assembly Operation Record	Engine Test Record	Configuration Record	Discrepancy Record	Delivered-Engine Shortage Record	Inspection Record	Special Notes and Comments
Shipping	X	3-75												
Receiving		3-75												
Engine installation		3-75												
Engine removal		3-75												
Inspection													3-95	
Log book audit		3-75												
Checkout			3-77	3-78	3-79			X						
Gimballing							3-82							
Static firing						X	X	X	3-84					
Modification	X									3-85				
Discrepancy disposition (UCR)											3-90			
Clearing shortages												3-92		
Special or unusual conditions or events														3-96
Launch	X	3-75				X			X					

NOTE

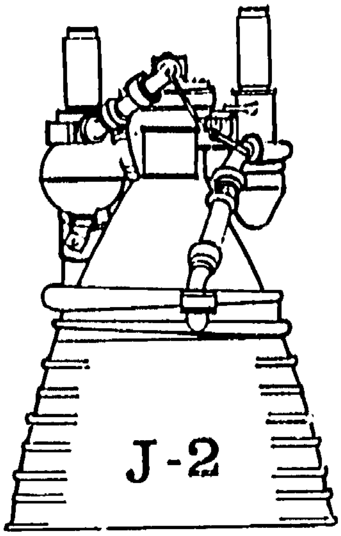
The figure numbers and X's represent the minimum log book forms affected by a specific task or event.

Figure 3-73. Minimum Log Book Entry Requirements

ROCKETDYNE
A DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

ENGINE IDENTIFICATION

MANUFACTURER OF ENGINE: ROCKETDYNE — A DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION



MODEL J-2 PART NUMBER 103826 SERIAL NUMBER J-2XXX

MODIFICATION DESIGNATION NUMBER

1 MD 3x5 11x13 20x23x25 28x32x34 38x40 51x53 61x64x68 70x72x76
80x82x84x86 88x97x99 101x103 107x116 118x122 123x127x130 134x138
143x148 153x155x158x160x163x168x176x185x188x218 219x221x226 227x229
230x244x254x256x267x276x278x287x289x291x301x304x312
313x316x319x322x324x330x332 334x338x343

CONTRACT NUMBER NAS8-19 CONTRACT SPECIFICATION NUMBER R-2158bS

2 ENGINE FINAL ACCEPTANCE DATE DNA 3 DD 250 DNA

APPROVAL SIGNATURES 4 Completed by ND-MTF

5 ROCKETDYNE ENGINEERING	DATE	6 ROCKETDYNE QUALITY CONTROL	DATE	7 PROCURING AGENCY REPRESENTATIVE	DATE

I. GENERAL INSTRUCTIONS.

The Engine Identification form must be reviewed and a new form completed whenever the engine, or responsibility for the engine, is transferred to a new site or organization so as to reflect the configuration of the engine at the time of transfer.

NOTE

Before engine transfer, the modification designation number must be updated to reflect completed retrofit action by marking up a copy of the last form completed.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1 MODIFICATION DESIGNATION NUMBER - Enter, in numerical order, all MD numbers, representing configuration changes incorporated on engine during manufacture and retrofit action. MD number gaps (representing unincorporated MD changes), between MD numbers incorporated, must be indicated by an X regardless of number of unincorporated MD numbers.

NOTE

MD numbers incorporated before transfer to the present site may be obtained from existing Engine Identification forms. MD numbers incorporated after transfer to the present site may be obtained from the Configuration Record. (See figure 3-85.)

2 ENGINE FINAL ACCEPTANCE DATE - Enter DNA.

Figure 3-74. Engine Identification (Sheet 1 of 2)

3 DD 250 - Enter DNA.

4 Enter (at bottom right corner) words "Completed by," followed by organization designation and location of organization responsible for transferring engine.

5 ROCKETDYNE ENGINEERING - Enter signature and date of signature of individual making entries.

6 ROCKETDYNE QUALITY CONTROL - Enter signature and date of signature of Contractor quality control personnel verifying accuracy and completeness of entries.

7 PROCURING AGENCY REPRESENTATIVE - Enter signature and date of signature of Government representative verifying accuracy and completeness of entries.

Figure 3-74. Engine Identification (Sheet 2 of 2)

TRANSFER RECORDS—ENGINE HISTORY								
MODEL J-2					ENGINE S/N J-2XXX			
1 ORGANIZATION AND LOCATION	2 DATE				3 TEST FACILITY AND/OR VEHICLE DESIGNATION	4 ACCUMULATED TIME	5 INSPECTION	
	SHIPPED	RECEIVED	INSTALLED	REMOVED			CONTRACTOR	GOVERNMENT
RD-CANO Log Book Audit	17 Aug 65					448.9		
MDC-HB Log Book Audit		17 Aug 65				448.9		
MDC-HB			18 Nov 65		SIVB 501	448.9		
MDC-HB				16 Dec 65	SIVB 501	448.9		
MDC-HB			11 Jan 66		SIVB 205	448.9		
MDC-HB Log Book Audit	8 Apr 66				SIVB 205	448.9		
MDC-STC Log Book Audit		13 Apr 66			SIVB 205	448.9		
MDC-STC			13 Apr 66		BETA III	448.9		
MDC-STC				5 Jul 66	BETA III	886.4		
MDC-STC Log Book Audit	7 Apr 68				SIVB 205	886.4		
MDC-KSC Log Book Audit		8 Apr 68			SIVB 205	886.4		
MDC-KSC Log Book Audit			16 Apr 68		Launch Complex 34	886.4		
Launched				11 Oct 68	Launch Complex 34	886.4		

I. GENERAL INSTRUCTIONS.

Entries must be made on the Transfer Records--Engine History form whenever the engine or responsibility for the engine is transferred to or from another site or organization. In addition, entries must be made to record log book audits performed during shipping, receiving, and prelaunch operations. Engine installation and removal dates must also be entered.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1. ORGANIZATION AND LOCATION - Enter organization designation and location of organization responsible for shipping and/or receiving engine or installing and/or removing engine. Also indicate whether log book audit is accomplished.

2. DATE - Enter date opposite organization and location responsible for engine being shipped, received, installed, or removed, as applicable.

3. TEST FACILITY AND/OR VEHICLE DESIGNATION - Enter designation of test facility and/or vehicle into which engine is installed.

4. ACCUMULATED TIME - Enter total effective firing duration on engine at time of transfer, receipt, installation, or removal. Obtain accumulated time from Engine Test Record. (See figure 3-84.)

5. INSPECTION - Enter stamp of individual making entries. In case of a log book audit, enter date and stamp or signature of Contractor representative making entries and Government representative verifying accuracy and completeness of log book.

Figure 3-75. Transfer Records--Engine History (Sheet 1 of 2)

III. <u>OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.</u>

A. <u>ENGINE IDENTIFICATION</u>. If engine or responsibility for engine is transferred to a new site or organization, complete new Engine Identification form. (See figure 3-74.)

Figure 3-75. Transfer Records--Engine History (Sheet 2 of 2)

ENGINE WEIGHT RECORD

MODEL J-2 ENGINE S/N J-2XXX

DATE OF ORIGINAL WEIGHING 7 August 1965 WEIGHED PER SPEC. RA0220-3210 AMEND. #1 SPEC. WEIGHT, DRY 3,480 LB

DATE OF ENTRY	MODIFICATION INSTRUCTION NO. & DATE	DES CHG NO.	MD CONF NO.	MD WEIGHT CHANGE (LB)	MD ARM* (IN.)	MD MOMENT CHANGE (LB-IN)	NET WEIGHT DRY (LB)	NET ARM (IN)	NET MOMENT (LB - IN.)	INSPECTION CONTRACTOR	INSPECTION GOVERNMENT
ENGINE AND ACCESSORIES, AS DELIVERED							** 3,420	+28.6	97,936		
1	2	3	4	5	6	7	8	10	9	11	
26 Oct 65	R-5436-394 19 Jul 1965	J2-394R1	148	+5.3	-9.4	-50	3,425.3	+28.6	97,886		DNA
1 Jan 66	R-5436-399 3 Jan 1966	J2-399R1	163	-0.9	+14.7	-13.0	3,424.4	+28.6	97,873		DNA

**ENGINE MD NUMBER, AS ORIGINALLY WEIGHED MD 3x5 11x13 20x23x25 28x32x34 51x53 61x64x68 70x72x76 80x82x84x86 88x97x99x101x106 107x116 118x122 123x127x130 132x134x138 143x152 153x158

* HORIZONTAL ARM IS REFERENCED FROM THE CENTERLINE OF THE GIMBAL BEARING, PLUS (+) BEING IN THE AFT DIRECTION.

I. GENERAL INSTRUCTIONS.

Entries must be made in the Engine Weight Record whenever a retrofit modification is completed that effects an engine weight change.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

NOTE

If the form does not contain the "**Engine MD Number, as Originally Weighed" block, the data in this block may be obtained from the Engine Identification form (see figure 3-74) prepared at engine delivery.

1 DATE OF ENTRY - Enter date retrofit modification installation is complete.

NOTE

Entries for steps 2 through 7 must be obtained from the applicable Modification Instruction.

2 MODIFICATION INSTRUCTION NO. AND DATE - Enter Modification Instruction number and date of publication.

3 DES. CHG. NO. - Enter design change (ECP) number including appropriate revision number.

4 MD CONF. NO. - Enter modification designation (MD) number(s) applicable to kit(s) installed.

5 MD WEIGHT CHANGE (LB) - Enter weight change resulting from installation of applicable kit. Indicate if weight is added (+) or subtracted (-).

6 MD ARM* (IN.) - Enter arm length applicable to kit installed. Indicate if arm is plus (+) or minus (-).

7 MD MOMENT CHANGE (LB-IN.) - Enter moment change applicable to kit installed. Indicate if moment change is plus (+) or minus (-).

8 NET WEIGHT DRY (LB) - Enter result (sum or remainder) of adding weight change, if plus (+), to last-listed net weight dry or of subtracting weight change, if minus (-), from last-listed net weight dry.

Figure 3-76. Engine Weight Record (Sheet 1 of 2)

9 NET MOMENT (LB-IN.) - Enter result (sum or remainder) of adding MD moment change, if plus (+), to last-listed net moment or of subtracting MD moment change, if minus (-), from last-listed net moment.

10 NET ARM (IN.) - Enter result (quotient) of dividing revised net moment by revised net weight.

11 INSPECTION. Enter stamp or signature of Contractor representative making entry. Enter DNA in remaining inspection column.

Figure 3-76. Engine Weight Record (Sheet 2 of 2)

SEQUENCE TIMING RECORD

MODEL J-2 ENGINE S/N J-2[illegible]

❶ TEST	❷ DATE	MFV OPEN (MS) DELAY	MFV OPEN (MS) TRAVEL	ASI VALVE OPEN (MS) START SIGNAL TO OPEN	FUEL BLEED VALVE CLOSE (MS) START SIGNAL TO CLOSED	OXID BLEED VALVE CLOSE (MS) START SIGNAL TO CLOSED	STDV OPEN (MS) DELAY	STDV OPEN (MS) TRAVEL	STDV CLOSE (MS) DELAY	STDV CLOSE (MS) TRAVEL	GG VALVE OPEN (MS) OXIDIZER POPPET DELAY	GG VALVE OPEN (MS) OXIDIZER POPPET TRAVEL	GG VALVE OPEN (MS) PLATEAU DEGREES TRAVEL	MOV OPEN (MS) FIRST STAGE DELAY	MOV OPEN (MS) FIRST STAGE TRAVEL	MOV OPEN (MS) FIRST STAGE DEGREES TRAVEL	MOV OPEN (MS) SECOND STAGE DELAY	MOV OPEN (MS) SECOND STAGE TRAVEL
ENG. SEQ. TEST PER DAC PROC. I-24136 REV 004 SEQUENCE #3	15 Aug [illegible]	❸ [illegible]	[illegible]	71	108	100	100	107	[illegible]	[illegible]	133	61	.550	57	51	130	302	❸ [illegible]

REMARKS: ❺

OTBV CLOSE (MS) W/O DELAY TO 90% CLOSED	OTBV CLOSE (MS) W/O DELAY TO FULL CLOSED	MOV CLOSE (MS) DELAY	MOV CLOSE (MS) TRAVEL	MFV CLOSE (MS) DELAY	MFV CLOSE (MS) TRAVEL	GG VALVE CLOSE (MS) OXIDIZER POPPET DELAY	GG VALVE CLOSE (MS) OXIDIZER POPPET TRAVEL	GG VALVE CLOSE (MS) FUEL POPPET CUTOFF SIGNAL TO CLOSED	ASI VALVE CLOSE (MS) CUTOFF SIGNAL TO CLOSED	OTBV OPEN (MS) CUTOFF SIGNAL TO OPEN	FUEL BLEED VALVE OPEN (SEC) CUTOFF SIGNAL TO FULL OPEN	OXID BLEED VALVE OPEN (SEC) CUTOFF SIGNAL TO FULL OPEN	TIMERS STDV DELAY (SEC)	TIMERS IGNITION PHASE (SEC)	TIMERS SPARKS DENERGIZED (SEC)	TIMERS HELIUM CONTROL DENERGIZED (SEC)	INSPECTION CONTRACTOR	INSPECTION GOVERNMENT
❸ [illegible]	303	73	118	81	[illegible]	101	18	[illegible]	37	870	[illegible]	[illegible]	[illegible]	.558	[illegible]	❸ [illegible]	❹	DNA

SUPPLEMENTAL SEQUENCE DATA SHEET

Model J-2 Engine S/N J-2XXX

❶ Test	❷ Date	MRCV to OPEN at Engine Start Delay	MRCV to OPEN at Engine Start Motion	MRCV to CLOSE at M/S +5 sec Delay	MRCV to CLOSE at M/S +5 sec Motion	MRCV to OPEN at MR Shift Delay	MRCV to OPEN at MR Shift Motion	Inspection
ENG SEQ TEST PER DAC PROC I-24136 REV 004	15 Jun 73	❸ 239	158	305	244	107	❸ 135	❹

Figure 3-77. Sequence Timing Record (Sheet 1 of 2)

I GENERAL INSTRUCTIONS.

Entries must be made in the Sequence Timing Record and Supplemental Sequence Data Sheet whenever valve and timer operating times are checked.

NOTE

If not included in the log book, blank forms must be inserted at the end of the Component Calibration Data section.

II. DETAILED INSTRUCTIONS.

Complete forms as follows:

1. TEST - Enter purpose and location of test. If several tests are conducted on same date, make separate entries in order of occurrence. Enter codes here for comments in Remarks block. (Only sequence tests used to determine engine valve times need be recorded. Sequence tests run for other reasons do not have to be recorded.)

2. DATE - Enter date test is completed.

3. VALVE AND TIMER COLUMNS - Enter timing values or degrees travel, as applicable, in each column.

NOTE

Only final values should be entered for a series of tests run to determine orifice sizes for retiming the engine.

4. INSPECTION - Enter stamp or signature of Contractor representative making entries. Enter DNA in remaining inspection column in Sequence Timing Record.

5. REMARKS - Enter any changes made to engine to obtain required values, such as valve or orifice replacements.

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. HELIUM REGULATOR ASSEMBLY OPERATION RECORD. If helium control valve is actuated or deactuated with pressure applied to helium regulator assembly, make entry in Helium Regulator Assembly Operation Record. (See figure 3-83.)

B. CHECKOUT NOTES AND COMMENTS. If unusual or noteworthy conditions or events are encountered during checkout, make an entry on the Checkout Notes and Comments form. (See figure 3-80.)

Figure 3-77. Sequence Timing Record (Sheet 2 of 2)

FLIGHT INSTRUMENTATION CHECKOUT

MODEL J-2 ENGINE S/N J-2XXX

CHANNEL NUMBER	PRINTER IDENTIFICATION	PARAMETER							
		1	DATE	9 Aug 65	29 Jan 68	28 Feb 68	10 Sep 68		
		2	PURPOSE AND LOCATION	ENGINE ACCEPTANCE RD-CANO	INSTALLED PER J2-594 MDC-STC	INSTALLED PER FORM# J2-SAC-68-6x MDC-STC	INSTRUMENT-ATION CHECKOUT J2-647 KSC		
		5	INSPECTION						
		PRESSURES 3	AMBIENT PRESSURE (IN-HG)				29.96		
1	1	FUEL PUMP DISCHARGE 4	INITIAL	-0.008					
			LOW CALIBRATE	01997					
			HIGH CALIBRATE	4.005					
2	2	OXIDIZER PUMP DISCHARGE	INITIAL	0.030					
			LOW CALIBRATE	1.036					
			HIGH CALIBRATE	4.035					
3	3	THRUST CHAMBER D0001	INITIAL	0.043			0.035		
			LOW CALIBRATE	1.053			1.040		
			HIGH CALIBRATE	4.061			4.045		
4	4	GG CHAMBER D0010	INITIAL	0.069			0.035		
			LOW CALIBRATE	1.079			1.040		
			HIGH CALIBRATE	4.090			4.060		
5	5	HELIUM TANK D0019	INITIAL		0.025		0.000		
			LOW CALIBRATE		1.020		0.865		
			HIGH CALIBRATE		3.989		3.870		
6	6	START TANK D0017 4	INITIAL			~~0.030~~	0.000		
			LOW CALIBRATE			~~0.979~~	6 1.005		
			HIGH CALIBRATE			~~0.946~~	4.000		

I. GENERAL INSTRUCTIONS.

Entries must be made on the Flight Instrumentation Checkout forms whenever a checkout is accomplished that records the noted values and/or other closely related values required by a given test objective for which no specific log book entries are required.

NOTE

Where flight instrumentation checkout values are monitored on a continual basis by stage automatic checkout equipment, recording of the values in the log book is required only after stage acceptance test and after CDDT, but before launch.

- If not included in the log book, blank forms (a total of nine sheets similar to and including the one shown) must be inserted at the end of the Components Calibration Data section.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1 DATE - Enter date checkout is completed. On continuation sheets enter date above first line of applicable column.

2 PURPOSE AND LOCATION - Enter purpose for and location of checkout.

3 AMBIENT PRESSURE (IN-HG) - Enter ambient pressure recorded at time final values are obtained.

4 Enter values obtained for applicable listed parameters. If a new parameter is added for an unused channel, use appropriate blank space. If a new parameter replaces an existing parameter on same channel, line out old parameter and previously recorded values. Enter new parameter with appropriate note of explanation.

Figure 3-78. Flight Instrumentation Checkout (Sheet 1 of 2)

5 INSPECTION - Enter stamp or signature of individual making entries.

6 Void previous values that are affected by component replacement or repairs. Remarks regarding component replaced, or extent of repairs, and date must be made on the Checkout Notes and Comments form. (See figure 3-80.)

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. CHECKOUT NOTES AND COMMENTS. If during the performance of checkout, component replacement and/or repair must be made to obtain required checkout values, make appropriate explanations on Checkout Notes and Comments form. (See figure 3-80.)

Figure 3-78. Flight Instrumentation Checkout (Sheet 2 of 2)

LEAKAGE, FLOW, AND TURBOPUMP TORQUE TESTS

MODEL J-2 ENGINE S/N J-2XXX

1	DATE	6 Aug 65	12 Feb 68				
	2 PURPOSE AND LOCATION	ENGINE ACCEPTANCE RD-CANO	T/C LEAK TEST RD-SB				
3	INSPECTION						
ANTI-FLOOD CHECK VALVE CRACKING PRESSURE 4	PSIG	110					
ANTI-FLOOD CHECK VALVE RESEAT LEAKAGE	SCIM	0					
ANTI-FLOOD CHECK VALVE SEAT LEAKAGE	SCIM	0					
ASI OXIDIZER VALVE SEAT LEAKAGE	SCIM	0					
FUEL BLEED VALVE LEAKAGE	SCIM	0					
FUEL JACKET PURGE CHECK VALVE REVERSE LEAKAGE	SCIM	~~0.7~~ 5	1.2				
FUEL PUMP (BREAKAWAY) TORQUE	IN.-LBS	20					
FUEL PUMP (RUNNING) TORQUE	IN.-LBS	20					
FUEL PUMP SECONDARY SEAL LEAKAGE	SCIM	2.0					
FUEL PUMP OMNI SEAL AND GG CONTROL VALVE FUEL POPPET LEAKAGE	SCIM	0					
FUEL PUMP PRIMARY SEAL LEAKAGE	SCIM	226.8					
FUEL SYSTEM LEAKAGE 4	SCIM	0					

I. GENERAL INSTRUCTIONS.

Entries must be made on the Leakage, Flow, and Turbopump Torque Tests forms whenever a checkout is accomplished that records the noted values and/or other values required by a given test objective for which no specific log book entries are required.

NOTE

If not included in the log book as delivered, new (blank) Leakage, Flow, and Turbopump Torque Tests forms (a total of seven sheets similar to and including the one shown) must be inserted for entries to be made after engine delivery.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1 DATE - Enter date checkout is completed. On continuation sheets enter date above first line of applicable column.

2 PURPOSE AND LOCATION - Enter purpose for and location where checkout is accomplished.

3 INSPECTION - Enter stamp or signature of individual making entries.

4 Enter values obtained for applicable listed items.

5 Void previous values that are affected by component replacement or repairs. (Refer to paragraph 3.8.4.8.) Remarks regarding components replaced or extent of repairs, and date must be made on Checkout Notes and Comments form. (See figure 3-80.)

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. CHECKOUT NOTES AND COMMENTS. If

Figure 3-79. Leakage, Flow, and Turbopump Torque Tests (Sheet 1 of 2)

component replacement and/or repair is made so that checkout values are affected, make appropriate explanations on Checkout Notes and Comments form. (See figure 3-80.)

B. HELIUM REGULATOR ASSEMBLY OPERATION RECORD. If the helium control solenoid is actuated or deactuated with pressure applied to the helium regulator assembly, make an entry in the Helium Regulator Assembly Operation Record. (See figure 3-83.)

Figure 3-79. Leakage, Flow, and Turbopump Torque Tests (Sheet 2 of 2)

MODEL J-2 CHECKOUT NOTES AND COMMENTS ENGINE S/N J-2XXX

1

During MDC all-systems test, start tank pressure transducer No. 2 exhibited the following values which exceeded the allowable 2% tolerance: ambient, 0.538 vdc; low, 1.527 vdc; high, 4.390 vdc. UCR R-003292 written. Removed and replaced transducer with like item.

Rocketdyne Engineer J. R. Norman

Date 28 February 1968

I. GENERAL INSTRUCTIONS.

Entries must be made on the Checkout Notes and Comments form whenever unusual or noteworthy conditions or events are encountered during checkout that affected or could affect checkout values.

NOTE

If not included in the log book as delivered, this form must be inserted after engine delivery to record unusual or noteworthy checkout conditions and events.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1 Enter a brief, concise description of conditions and events that affected, or could affect, checkout values. Include a description of action taken, if any, to correct conditions and allow conclusion of checkout tasks, as required. Include dates, times, hardware identification, and personnel, as necessary, to allow reconstruction and analysis of conditions and events as they occurred.

Figure 3-80. Checkout Notes and Comments

OPERATIONAL DATA ENGINE PERFORMANCE SUMMARY

MODEL J-2 ENGINE S/N J-2XXX

① TEST NUMBER	② DATA REDUCTION METHOD AND SLICE TIME	STEADY STATE PERFORMANCE AT STANDARD CONDITIONS: ENGINE THRUST ③ KIPS	ENGINE MIXTURE RATIO ④ O/F	ENGINE SPECIFIC IMPULSE ⑤ SEC	THRUST TRANSIENT PERFORMANCE AT SITE CONDITIONS: ENGINE START SIGNAL TO M/S INITIATE ⑥ SEC	ENGINE START SIGNAL TO 90% THRUST ⑦ SEC	MAXIMUM THRUST INCREASE RATE ⑧ LBS/10MS	CUTOFF SIGNAL TO 5% THRUST ⑨ SEC	CUTOFF IMPULSE ⑩ LB-SEC
SIVB 203 [illegible]	60	225,637	5.535	420.0	2.616	3.307	6670	0.680	43480
	400	181,297	4.607	428.9					

I. GENERAL INSTRUCTIONS.

Entries must be made in the Operational Data Engine Performance Summary whenever engine hot-fire tests are conducted.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1. TEST NUMBER - Enter letters or numerals indicating test facility vehicle/stage identification and test sequence number, if applicable.

2. DATA REDUCTION METHOD AND SLICE TIME - Enter time in seconds from engine start signal at which data slice is taken.

3. ENGINE THRUST - Enter value of engine thrust at time recorded in step 2. If thrust is not recorded, enter chamber pressure.

4. ENGINE MIXTURE RATIO - Enter value for engine mixture ratio to nearest 0.001 unit as possible.

5. ENGINE SPECIFIC IMPULSE - Enter value for rated specific impulse to nearest 0.1 second.

6. ENGINE START SIGNAL TO M/S INITIATE - Enter DNA.

7. ENGINE START SIGNAL TO 90% THRUST - Enter lapsed time from engine start signal to time thrust reaches 90% of steady-state value.

8. MAXIMUM THRUST INCREASE RATE - Enter thrust buildup rate observed over a 10-millisecond interval representing most rapid increase in thrust to nearest 100 pounds per 10 milliseconds.

Figure 3-81. Operational Data Engine Performance Summary (Sheet 1 of 2)

OPERATIONAL DATA
GIMBAL TEST RECORD

MODEL J-2 ENGINE S/N J-2XXX

DATE (1)	TEST NUMBER (2)	TEST LOCATION (3)	TEST TYPE (4)	GIMBAL PATTERN (1) (5)	GIMBAL ANGLE (DEGREES) (6)	GIMBAL CYCLES (7)	PERCENT DESIGN LIFE EXPENDED — THIS TEST (8) — GIMBAL BEARING	THIS TEST — CUSTOMER CONNECT AND INLET DUCTS	CUMULATIVE (9) — GIMBAL BEARING	CUMULATIVE — CUSTOMER CONNECT AND INLET DUCTS	ENGINEERING SIGNATURE (10)
24 Feb 66	Pre-Test 313-018	Rocketdyne VTS-2	Clearance and dry gimbal check	A	10.2	2	0.714	0.702	0.714	0.702	
				B	7.2	4	0.584	0.488	1.298	1.190	
				C	7.5	4	0.660	0.540	1.958	1.730	
				D	10.0	4	1.356	1.312	3.314	3.042	
				E	10.1	4	1.404	1.380	4.718	4.422	
2 Mar 66	1040964	MDC-100 A3	Slow manual fill and bleed	A	7	1	0.142	0.133	4.860	4.555	
5 Mar 68		Component Removed: Fuel Pump Inlet Duct, P/N 408280, S/N 4067601									
7 Mar 68	(11)	Component Installed: Fuel Pump Inlet Duct, P/N 408280-11, S/N 409739								0.000(a)	
2 Apr 68	DOP-E018	KSC	Engine clearance	A	+7.3 -6.1	1.5	.23	.18	5.090	4.735 0.180(a)	

(1) A-SQUARE, B-NO.1 ACTUATOR INDEPENDENTLY, C-NO. 2 ACTUATOR INDEPENDENTLY, D-BOTH ACTUATORS IN PHASE, E-BOTH ACTUATORS OUT OF PHASE, OTHER-SPECIFY.

(a) Design Life Expended On Replacement Fuel Pump Inlet Duct.

I. GENERAL INSTRUCTIONS.

Entries must be made in the Operational Data Gimbal Test Record whenever gimbals are actuated.

NOTE

If not included in the log book, this form must be inserted, and all data on the form that is in the log book must be entered on the new form as outlined in steps 1 through 9.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

(1) DATE - Enter date test is conducted (completed).

(2) TEST NUMBER - Enter letters and/or numbers that indicate testing facility, vehicle, or stage test sequence number.

(3) TEST LOCATION - Enter exact location of engine being tested, including vehicle and/or test facility designation, engine position in stage, and geographical location.

(4) TEST TYPE - Enter type of test being conducted, specifying hot fire or checkout. Indicate single engine in cluster, or multi-engines in cluster.

(5) GIMBAL PATTERN - Enter code (found at bottom of form) to describe gimbal motion. For unusual gimbal programming, specify pattern used. Separate entries must be made for each gimbal, pattern, or programmed change in amplitude during a test.

(6) GIMBAL ANGLE (DEGREES) - Enter maximum engine deflection angle to nearest 0.1 degree for each gimbal pattern or programmed change in amplitude. If maximum deflection varies during a cycle or cycles of a gimbal pattern, enter the average. For square patterns the maximum deflections apply to corner positions only.

Figure 3-82. Operational Data Gimbal Test Record (Sheet 1 of 2)

(7) GIMBAL CYCLES - Enter number of cycles run for each gimbal pattern or angle; however, for square pattern, enter 1.5 times number of cycles.

NOTE

A gimbal cycle is defined as deflection from the null position to any gimbal angle, deflection back through null to the opposite angle, and then return to null. For a square pattern a cycle is defined as deflection from null to any corner, then to the other three corners in order without returning to null, then to the original corner, and then to null. Any gimbal movement that is less than the defined cycle must be recorded as a half cycle.

(8) PERCENT DESIGN LIFE EXPENDED - Enter percent of design life expended for gimbal bearing and customer connect and inlet ducts determined by obtaining the ratio of number of cycles run to limiting number of cycles (contained in section II of this manual, Gimbaling Limitations) by multiplying actual cycles by 100 and dividing result (product) by limiting cycles to obtain percent of design life expended.

(9) Enter cumulative percent of design life expended for gimbal bearing and customer connect and inlet ducts obtained by adding percentages of this test to last entry in the applicable Cumulative column.

(10) ENGINEERING SIGNATURE - Enter signature of individual making entries.

(11) Enter date, part name, part number, and serial number of component removed and of component installed when any component having gimbaling limitations is replaced. Enter percent of design life expended on replacement component. The following engine components have gimbaling limitations:

Gimbal bearing
Fuel inlet duct
Oxidizer inlet duct
Thrust chamber jacket purge line
Oxidizer pump primary seal drain line
Start tank vent-and-relief valve drain line
Helium tank fill line
Start tank vent valve control line
Start tank initial fill line
Heat exchanger helium inlet line (SIVB stage only)
Turbopump and gas generator purge line
Fuel pump drain line
Hydrogen tank pressurization line
Fuel bleed line
Oxidizer tank pressurization line
Oxidizer bleed line

NOTE

Following the replacement of a component, entries must continue to be made. Separate entries must be maintained for each component after replacements are installed and when design life is different for each.

Figure 3-82. Operational Data Gimbal Test Record (Sheet 2 of 2)

9 **CUTOFF SIGNAL TO 5% THRUST** - Enter elapsed time between engine cut-off signal and time that thrust reaches 5% of steady stage value observed at engine cutoff signal to nearest 0.01 second.	10 **CUTOFF IMPULSE** - Enter computed cut-off value to nearest 100 lb-sec.

Figure 3-81. Operational Data Engine Performance Summary (Sheet 2 of 2)

J-2 START TANK PRESSURE CYCLE LIFE

ENGINE NO. J-XXXX VEHICLE SA-XXX POSITION XX P/N XXXX

S/N XXXXXX MFG. NAR-Columbus

① NUMBER CYCLES AT SAME CONDITION N	② PRESSURE CYCLE P_{MIN} TO P_{MAX} (PSIG) (PSIG)	③ R $\left(\frac{P_{MIN}}{P_{MAX}}\right)$	④ EQUIVALENT FRACTION OF 0 TO P_{MAX} CYCLE S	⑤ FLAW GROWTH RATE, da/dn, AT CURRENT FLAW SIZE AND P_{MAX} (μIN)	⑥ INCREMENT OF FLAW GROWTH ①x④x⑤ (μIN)	⑦ CURRENT MAXIMUM FLAW SIZE (μIN)	⑧ CYCLE LIFE REMAINING (0-1400 PSIG)
	PROOF PRESSURE 1,850 PSIG					160,600	33
1	0-1,240	0	1	162	162	160,762	32
1	0-1,207	0	1	140	140	160,902	32
1	0-1,328	0	1	275	275	161,177	31
1	550-1,100	0.500	0.415	75	31	161,208	31
1	0-1,450	0	1	493	493	161,701	30
4	1,200-1,400	0.857	0.020	405	32	161,733	29
1	0-1,350	0	1	320	320	162,053	29

I. GENERAL INSTRUCTIONS.

Entries must be made on the J-2 Start Tank Pressure Cycle Life Work Sheet when the tank is pressurized through a pressure cycle as defined in section II.

II. DETAILED INSTRUCTIONS.

Refer to section II (Start Tank Pressure Cycle Life) for detailed instructions on completing J-2 Start Tank Pressure Cycle Life Work Sheet.

Figure 3-82A. J-2 Start Tank Pressure Cycle Life Work Sheet

HELIUM REGULATOR ASSEMBLY OPERATION RECORD

MODEL J-2 HELIUM REGULATOR ASSEMBLY P/N 556947-141 S/N 4080310 ENGINE S/N J-2XXX

DATE	OPERATION IN PROGRESS	DOCUMENT	PARAGRAPH NUMBER	HELIUM CONTROL (ON OR OFF)	HELIUM TANK OR REGULATOR INLET PRESSURE PRIOR TO HELIUM CONTROL ACTUATION OR DE-ACTUATION (PSIG)	PRESSURE APPLIED TO HELIUM TANK OR REGULATOR INLET AFTER ACTUATION OF HELIUM CONTROL (PSIG)	AMBIENT (A) OR CRYOGENIC (C) OPERATION
1	2	3	4	5	6	7	8
7 Feb 68	Eng Sys Leak Check	DOP-C02-E013 V24117	DNA	On (8) Off (8)	1450 ±25 psig	1450 ±25 psig	A
28 Feb 68	Eng Sys Leak Check	DOP-C02-E013 V24117	DNA	On (8) Off (8)	1450 ±25 psig	1450 ±25 psig	A

I. GENERAL INSTRUCTIONS.

Entries must be made in the Helium Regulator Assembly Operation Record whenever the helium regulator is cycled. The helium regulator is cycled, (1) by energizing or deenergizing the helium control valve with the helium tank pressurized or (2) by pressurizing the helium tank with the helium control valve energized.

NOTE

If not included in the log book, a blank form must be inserted at the end of the Operational Data Log section.

- If the helium regulator assembly is replaced, this record must accompany the old part. A new record must be started for the new part, and all previous component data must be transferred to this form from the component record received with the new component.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1. DATE - Enter date of actuation or deactuation of helium control valve.

2. OPERATION IN PROGRESS - Enter operation in progress, such as: component test, oxidizer feed system flow test, pneumatic control system test, helium supply system mass-loss test, etc.

3. DOCUMENT - Enter number of applicable manual, specification, or other document requiring operation, including publication date.

4. PARAGRAPH NUMBER - Enter paragraph number of document requiring actuation or deactuation of helium control valve.

5. HELIUM CONTROL (ON OR OFF) - Enter ON for actuation during test and OFF for deactuation. Enter total number of ON and OFF actions for operation in progress.

6. HELIUM TANK OR REGULATOR INLET PRESSURE PRIOR TO HELIUM CONTROL VALVE ACTUATION OR DEACTUATION (PSIG) - Enter helium tank or regulator inlet pressure immediately prior to actuation or deactuation of helium control valve. If none, enter O.

7. PRESSURE APPLIED TO HELIUM TANK OR REGULATOR INLET AFTER ACTUATION OF HELIUM CONTROL VALVE (PSIG) - Enter helium tank or regulator inlet pressure if pressure is applied or increased after actuation of helium control valve. If pressure is not applied or increased after actuation of helium control valve, enter DNA.

8. AMBIENT (A) OR CRYOGENIC (C) OPERATION - Enter A for ambient or C for cryogenic operation.

Figure 3-83. Helium Regulator Assembly Operation Record

ENGINE TEST RECORD

MODEL J-2 ENGINE S/N J-2XXX

1 TEST NUMBER	2 TEST DATE	3 TEST DURATION	4 TOTAL DURATION	5 TOTAL STARTS	6 TEST COMMENTS	7 RESPONSIBLE ENGINEER
			448.9	5	Rocketdyne Acceptance Firing	
SIVB 205 C/D # 614064	2 Jun 66	437.5	886.4	6	Stage 2005 Acceptance Firing	

I. GENERAL INSTRUCTIONS.

Entries must be made in the Engine Test Record whenever the engine is operated at or exceeding 90 percent of designed engine thrust.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1 TEST NUMBER - Enter letters and/or numerals that designate site and/or vehicle identification, and enter test sequence number, if applicable.

2 TEST DATE - Enter date test is conducted.

3 TEST DURATION - Enter effective duration of each test to nearest 0.1 second measured from start tank discharge valve control signal to engine cutoff signal.

4 TOTAL DURATION - Enter accumulated effective duration of all tests of engine to nearest 0.1 second.

5 TOTAL STARTS - Enter accumulated starts of engine. "Engine Start" is the arrival of a start signal at engine interface.

6 TEST COMMENTS - Enter comments pertinent to test objectives, results, performance malfunctions, part failures, along with interactions between engine and stage/vehicle/facility systems, when applicable for evaluation of overall performance.

7 RESPONSIBLE ENGINEER - Enter signature of individual making entries.

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. OPERATIONAL DATA ENGINE PERFORMANCE SUMMARY. If engine hot-fire tests are conducted, entries must be made in the Operational Data Engine Performance Summary. (See figure 3-81.)

B. OPERATIONAL DATA GIMBAL TEST RECORD. If engine is gimbaled during static firing, make entries in Operational Data Gimbal Test Record. (See figure 3-82.)

C. HELIUM REGULATOR ASSEMBLY OPERATION RECORD. If helium control solenoid is actuated or deactuated during static firing, make entries in Helium Regulator Assembly Operation Record. (See figure 3-83.)

Figure 3-84. Engine Test Record

CONFIGURATION RECORD

MODEL J-2 ENGINE S/N J-2XXX

1 DESIGN CHANGE NO. AND DATE	2 DESCRIPTION OF CHANGE	3 MD NO	4 COMPLETION DATE	5 ORGANIZATION	INSPECTION CONTRACTOR	6 INSPECTION GOVERNMENT
J2-643R2	Replacement of Augmented Spark Igniter, R-3436-643 dated 23 Oct 1968.	328 330 332	26 Nov 68	RD-KSC		DNA
J2-624R1	Installation of Emergency Vent Valve, R-3436-624 dated 10 Dec 1968	316	22 Dec 68	RD-KSC		DNA
~~J2-553R1~~ 7	~~Capping of Start Tank Refill System~~	~~254~~ ~~347~~	~~25 Jan 69~~	~~RD-KSC~~		DNA

I. GENERAL INSTRUCTIONS.

Entries must be made in the Configuration Record whenever approved Modification Instructions are approved for incorporation on the engine. The completion of the modification will be recorded by date and the accomplishing organization.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1 DESIGN CHANGE NO. (AND DATE) - Enter design change (ECP) number, including latest revision number, when applicable. Obtain from applicable Modification Instruction.

NOTE

Date of ECP is not required, although indicated in the column heading of some forms.

2 DESCRIPTION OF CHANGE - Enter Modification Instruction Title, number, and date as obtained from applicable Modification Instruction.

3 MD NO. - Enter modification designation (MD) number(s) applicable to kit(s) installed. Obtain from applicable Modification Instruction.

4 COMPLETION DATE - Enter date modification installation is completed as required by Modification Instruction.

5 ORGANIZATION - Enter identification of organization accomplishing modification.

6 INSPECTION - Enter stamp or signature of Contractor representative making entries. Enter DNA in remaining inspection column.

7 Void entries when related MD changes are physically removed from engine. (Refer to paragraph 3.8.4.8.)

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. ENGINE WEIGHT RECORD. If a retrofit modification is completed that affects engine weight, make an entry in Engine Weight Record. (See figure 3-70.)

B. POST-DELIVERY SERIALIZED COMPONENT REPLACEMENT RECORD. If a Modification Instruction requires removal, replacement, installation, or part number changing of a serialized component, make entries in Post-Delivery Serialized Component Replacement Record. (See figure 3-87.)

C. POST-DELIVERY ORIFICE REPLACEMENT RECORD. If a Modification Instruction requires removal, replacement, or installation of an

Figure 3-85. Configuration Record (Sheet 1 of 2)

orifice, make entries in Post-Delivery Orifice Replacement Record. (See figure 3-88.)

D. ELECTRICAL CONTROL ASSEMBLY, PRIMARY AND AUXILIARY FLIGHT INSTRUMENTATION PACKAGES, AND SPARK IGNITER CABLE PRESSURIZATION RECORDS. If a Modification Instruction requires monitoring of pressure in, or pressurizing of electrical assemblies or spark cables, make entries in Electrical Control Assembly, Primary and Auxiliary Flight Instrumentation Packages, and Spark Igniter Cable Pressurization Records. (See figure 3-94.)

E. ENGINE IDENTIFICATION. If a Modification installation is completed or an MD change is physically removed from an engine, make appropriate changes on Engine Identification form. (See figure 3-74.)

Figure 3-85. Configuration Record (Sheet 2 of 2)

I. GENERAL INSTRUCTIONS.

Entries must be made in the Delivered Serialized Component Record whenever a serialized component, listed on the form, is replaced.

NOTE

Although log book forms will differ, the following detailed instructions will apply.

- If the log book does not have this form, replaced items must be lined out in the Pre-Delivery Serialized Component Replacement Record.

II. DETAILED INSTRUCTIONS.

1. Identify component that was replaced or reidentified and correctly void all obsolete entries for this component. (Refer to paragraph 3.8.4.8.)

Figure 3-86. Delivered Serialized Component Record

POST DELIVERY SERIALIZED COMPONENT REPLACEMENT RECORD

1 DEL J-2 ENGINE S/N J-2XXX

CARD ITEM I.D. NO.	2 PART NAME	3 PART NO.	4 SERIAL NO.	5 COMMENTS	INSTAL-LATION DATE 6	INSPECTION CON-TRACTOR	INSPECTION GOVERN-MENT 7
~~00~~ 8	~~Fast-Shutdown Valve Assembly P/A~~	~~556936~~	~~4077730~~	~~per ECP J2-387~~	~~12 Nov 67~~		DNA
010	Helium Tank Fill Hose (Anaconda American Brass Co)	NA5-260058-1	166	Ref. UCR 009264 FORR J2-HTF-67-122	29 Dec 67		DNA
043	Oxidizer Turbine Bypass Valve	409940	4086377	Ref. UCR 009755 FORR J2-HTF-68-17	5 Jan 68		DNA
002	Fast-Shutdown Valve Assembly	556936	5123461	Ref. UCR 009921 FORR J2-HTF-68-21	2 Feb 68		DNA

I. GENERAL INSTRUCTIONS.

Entries must be made in the Post-Delivery Serialized Component Replacement Record whenever a serialized component listed in Rocketdyne Configuration Report R-5788 is permanently removed, replaced, installed, or the part number is changed.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1 CARD I.D. NO. (ITEM NO.) - Enter card identification number for component being installed or having part number changed. Card identification numbers are assigned by Rocketdyne Configuration Report R-5788.

2 PART NAME - Enter part name of replacement or new component. If NA5 component, enter manufacturer's name.

3 PART NO. - Enter part number of replacement or new component or for component having part number changed. If NA5 component, make sure dash numbered suffix is included, if applicable.

4 SERIAL NO. - Enter serial number of replacement or new component to be installed or for component having part number changed.

5 COMMENTS - Enter reason for and/or number of document authorizing replacement, installation, or part number change.

6 INSTALLATION DATE - Enter date installation of replacement or new component is completed or when part number of component is changed.

7 INSPECTION - Enter stamp of Contractor representative making entries. Enter DNA in remaining Inspection column.

NOTE

Step 8 covers replacement or removal of components after their entry on the form.

8 Void the entry for component being permanently removed, replaced, or having part number changed. (Refer to paragraph 3.8.4.8.)

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. DELIVERED SERIALIZED COMPONENT RECORD. If a component listed in Delivered Serialized Component Record (figure 3-80) is replaced or has part number changed, void the entry for component. (Refer to paragraph 3.8.4.8.)

B. AGE CONTROL LOG FOR COMPONENT SYNTHETIC RUBBER ITEMS. If a component containing synthetic rubber items, or attached with synthetic rubber items in interface, is replaced, installed, or removed, make an entry on Age Control Log for Component Synthetic Rubber Items form. (See figure 3-91.)

C. INSTRUMENTATION ROAD MAPS. If a transducer or strain gage is removed, replaced,

Figure 3-87. Post-Delivery Serialized Component Replacement Record (Sheet 1 of 2)

or installed, make entries in Instrumentation Road Maps. (See figure 3-93.)

D. HELIUM REGULATOR ASSEMBLY OPERATION RECORD. If a helium regulator is removed, installed, or replaced, make appropriate entries in Helium Regulator Assembly Operation Record. (See figure 3-83.)

E. ELECTRICAL CONTROL ASSEMBLY, PRIMARY AND AUXILIARY FLIGHT INSTRUMENTATION PACKAGES, AND SPARK IGNITER CABLE PRESSURIZATION RECORDS. If an electrical control assembly, primary or auxiliary flight instrumentation package, or a spark igniter cable is replaced, make appropriate entries in Electrical Control Assembly, Primary and Auxiliary Flight Instrumentation Packages, and Spark Igniter Cable Pressurization Records. (See figure 3-94.)

Figure 3-87. Post-Delivery Serialized Component Replacement Record (Sheet 2 of 2)

I. GENERAL INSTRUCTIONS.

Entries must be made in the Delivered Orifice Record only when an existing orifice (listed on the form) is removed or replaced.

II. DETAILED INSTRUCTIONS.

NOTE

Although the appearance of the form may vary from that shown, these instructions are applicable to all Delivered Orifice Record forms.

Identify orifice that was replaced and correctly void all entries for this orifice. (Refer to paragraph 3.8.4.8.)

Figure 3-88. Delivered Orifice Record

POSTDELIVERY ORIFICE REPLACEMENT RECORD

MODEL J-2 ENGINE S/N J-2XXX

1 ORIFICE NAME	2 ORIGINAL		3 NEW		4 COMMENTS	5 DATE	6 INSPECTION	
	PART NO.	DIA.	PART NO.	DIA.			CONTRACTOR	GOVERNMENT
STDV Restrictor Check Valve Orifice Plug	556433	-187	556433	-191	Attempted to speed STDV opening response time during EKM checkout at MDC-HB	20 Oct 65		DNA
GG Opening Control Orifice	DNA	DNA	RD251-4115	-0052	Installed per ECBJ2-455R3.	22 Mar 66		DNA
Hydrogen Refill Line Orifice Plate	RD251-4117	-0099	503437-5	Blank	Changed per ECBJ2-353.	21 Feb 67		DNA

I. GENERAL INSTRUCTIONS.

Entries must be made in the Post-Delivery Orifice Replacement Record whenever an orifice listed in the Delivered Orifice Record is replaced, including those instances where replacement does not result in an orifice diameter change. New orifices installed by retrofit action must also be recorded.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1. ORIFICE NAME - Enter orifice name.
2. ORIGINAL - Enter part number of orifice removed. Enter first part of number in Part No. column. Enter suffix or dash number in Dia. column.

NOTE

The actual diameter in inches must not be listed in the Dia. column. Dash numbers (suffix numbers) or the orifice part number indicates diameter within specific tolerances.

3. NEW - Enter part number of orifice installed. Enter first part of number in Part No. column. Enter suffix or dash number in Dia. column.
4. COMMENTS - Enter reason for orifice replacement, installation, or removal.
5. DATE - Enter date replacement, installation, or removal is complete.
6. INSPECTION - Enter stamp or signature of Contractor representative making entries. Enter DNA in remaining Inspection column.

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. DELIVERED ORIFICE RECORD. If orifices listed in Orifice Record have subsequently been replaced or removed, void the related entry in Delivered Orifice Record. (See figure 3-88 and refer to paragraph 3.8.4.8.)

Figure 3-89. Post-Delivery Orifice Replacement Record

DISCREPANCY RECORD

MODEL J-2 ENGINE S/N J-2XXX

DISCREPANCY (1)	UCR NO (2)	ACTION TAKEN (3)	DATE (4)	INSPECTION (5) CONTRACTOR	GOVERNMENT
Unable to remove fuel turbine inlet temperature transducer for inspection following stage acceptance.	001510	Used as is. Hot fire data and post-hot-fire resistance checks were satisfactory.	16 Jun 66		DNA
Start tank vent-and-relief valve failed to close.	001505 001506	Removed and replaced. FORR J2-KSC-68-V31	6 Jun 66		DNA
Numerous superficial scratches on face of bolted flange (interface) could cause leaks.	DNA	Ref: FARR A188657	22 Feb 66		DNA

I. GENERAL INSTRUCTIONS.

Entries must be made in the Discrepancy Record whenever a discrepancy is noted that requires Unsatisfactory Condition Report (UCR) or material review type action.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1. DISCREPANCY - Enter brief description of discrepancy and date noted.

2. UCR NO. (OFR NO.) - Enter number of Unsatisfactory Condition Report written against discrepancy. Enter DNA, and signature of person entering, if UCR is not written.

3. ACTION TAKEN - Enter brief description of action taken to clear discrepancy. Reference all applicable Government or Contractor UCRs written against same discrepancy. Enter document authorizing corrective action, if applicable.

4. DATE - Enter date discrepancy is cleared.

5. INSPECTION - Enter stamp or signature of Contractor representative making entries. Enter DNA in remaining Inspection column.

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. POST-DELIVERY SERIALIZED COMPONENT REPLACEMENT RECORD. If a discrepancy disposition requires replacement of a serialized component that is listed in Rocketdyne Configuration Report R-5788, make entries in Post-Delivery Serialized Component Replacement Record. (See figure 3-87.)

B. POST-DELIVERY ORIFICE REPLACEMENT RECORD. If a discrepancy disposition requires replacement of an orifice, make entries in Post-Delivery Orifice Replacement Record. (See figure 3-89.)

Figure 3-90. Discrepancy Record

AGE CONTROL LOG FOR COMPONENT SYNTHETIC RUBBER ITEMS

MODEL J-2 ENGINE S/N J-2XXX

1 ITEM	2 PART NAME	3 PART NO	4 SERIAL NO.	5 MFG CODE	6 SPEC NO	7 INSTALL DATE	8 REPLACEMENT DATE	10 INSPECTION	9 DATE REPLACED
01	11 ~~P/A Shutoff Valve Assy, NC~~	~~556970~~	~~4067946~~	~~02602~~	~~RA0115-122~~	~~1065~~	~~1068~~		~~4067~~
02	P/A Purge Control Valve	557823	4067928	02602	RA0115-122	2065	2068		
19	P/A Shutoff Valve Assy, NC	556970	5047982	02602	RA0115-122 MSFC-STD-105	3067	3073		

I. GENERAL INSTRUCTIONS.

Entries must be made on the Age Control Log for Component Synthetic Rubber Items form whenever a component containing synthetic rubber items is replaced, installed, or removed.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1. ITEM - Enter item number. Assign consecutive numbers for each entry.
2. PART NAME - Enter nomenclature of component containing synthetic rubber items.
3. PART NO. - Enter part number of component.
4. SERIAL NO. - Enter serial number of component.
5. MFG CODE - Enter applicable code number of component manufacturer.
6. SPEC NO. - Enter applicable process specification number that specifies age control for component rubber items.
7. INSTALL DATE - Enter date (quarter of year and year) of installation of rubber items in component.
8. REPLACEMENT DATE - Enter date (quarter of year and year) component rubber items must be replaced.
9. DATE REPLACED - Enter date (quarter of year and year) rubber items are actually replaced. A new entry is required if component is replaced.
10. INSPECTION - Enter stamp or signature of individual making entries.
11. Void entry of component being replaced or removed. (Refer to paragraph 3.8.4.8.)

Figure 3-91. Age Control Log for Component Synthetic Rubber Items

DELIVERED ENGINE SHORTAGE RECORD

MODEL J-2 ENGINE S/N J-2XXX

ITEM NO	PART NAME	PART NO	DATE ENTERED	INSPECTION CONTRACTOR	INSPECTION GOVERNMENT	(1) DATE CLEARED	(2) COMMENTS	(3) INSPECTION CONTRACTOR	(3) INSPECTION GOVERNMENT
727	Helium Tank Pressure Transducer (SN1)	NA5-27412T35T	13 Sep 67			3 Jan 68	NA5-27440T35T (alternate) installed S/N 4367541		DNA
DNA	Packing	MS29513-021	13 Sep 67			3 Jan 68			DNA

I. GENERAL INSTRUCTIONS.

Entries must be made in the Delivered-Engine Shortage Record whenever a listed shortage item is received and installed on the engine.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1. DATE CLEARED - Enter date component is installed, or enter date loose equipment is received.

2. COMMENTS - Enter comments not provided elsewhere including identification information, such as part number, if different than original item, and serial number, if applicable.

3. INSPECTION - Enter stamp of Contractor representative making entries. Enter DNA in remaining Inspection column.

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. POST-DELIVERY SERIALIZED COMPONENT REPLACEMENT RECORD. If a serialized component listed in Rocketdyne Configuration Report R-5788 is installed, make entries in Post-Delivery Serialized Component Replacement Record. (See figure 3-87.)

B. POST-DELIVERY ORIFICE REPLACEMENT RECORD. If an orifice is installed, make entries in Post-Delivery Orifice Replacement Record. (See figure 3-89.)

Figure 3-92. Delivered-Engine Shortage Record

ROCKETDYNE

J-2 PRIMARY INSTRUMENTATION SYSTEM ROAD MAP

ENGINE S/N [illegible] DATE [illegible]

PRIMARY INSTRUMENTATION PACKAGE	P/N [illegible]	S/N [illegible]	SEE J-2 PRIMARY INSTRUMENTATION PACKAGE ROAD MAP FOR TRANSDUCERS INSTALLED IN PACKAGE

TAP NO.	PARAMETER	RANGE	NAS SPECIFICATION	MANUFACTURER'S IDENTIFICATION			REDUCED CALIBRATION DATA							INSP STAMP
				NAME	PART NO.	SERIAL NO.	A_0	A_1	A_2	A_3	A_4	A_5	A_6	
[illegible]	FIP Discharge Temp No. 1	-425° to -400°F	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
~~[illegible]~~	~~[illegible]~~	~~0 to 1,000°F~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	3
[illegible]	Electrical Control Pkg Temp No. 1	-300° to 200°F	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
2 [illegible]	Fuel Turbine Inlet Temp	0 to 1,000°F	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4

TAP	PARAMETER	RANGE	NAS-SPEC	NAME	PART NO.	SERIAL NO.	A_0 (VOLTS)	A_1 (VOLTS/PSIA)	20% ON (PSIA)	80% ON (PSIA)	
1	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	3
2	FIP Interstage Press	0 to 300 psia	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4

I. GENERAL INSTRUCTIONS.

Entries must be made in the Instrumentation Road Maps whenever a transducer is replaced, installed, or removed.

NOTE

The instructions for completing road map forms when strain gages are replaced, installed, or removed are similar to those described in this figure.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

NOTE

Only one sample of the road maps is shown; all others will be completed in a similar manner.

1. Void, when applicable, all data for transducer being removed. (Refer to paragraph 3.8.4.8.) Individual Transducer Data Sheets, manufacturer's test and calibration data sheets, IBM printouts, and IBM cards for removed transducer must be removed from log book backup data and routed with the removed transducer.

2. Whenever a transducer is being replaced or added to engine, enter all data for transducer being installed. Obtain data from Individual Transducer Data Sheet shipped with new or replacement transducer.

NOTE

Individual Transducer Data Sheets, manufacturer's test and calibration data sheets, IBM printouts, and IBM cards are not included in the log book but are retained as part of log book backup data.

3. Enter stamp of individual verifying removal of voided entry.

4. Enter stamp of individual making entries.

Figure 3-93. Instrumentation Road Maps

SPARK CABLE PRESSURIZATION RECORD

CABLE IDENTITY No. 1 GG (G3) ❶ P/N NA5-27448T1-1 ❷ S/N 296 ❸ ENGINE S/N J-2XXX

PRESSURE MONITORING							
DATE:	9 Dec. 70	4					
REASON (SEE CODE BELOW):	EFIR 48	5					
FORR NO:	KSC-70-XX	6					
MONTHS SINCE LAST MONITORED OR PRESSURIZED:	5	7					
MEASURED TEMPERATURE (°F):	66°	8					
MEASURED PRESSURE (PSIG):	20.0	9					
PRESSURE CORRECTED TO 70° F (PSIG):	20.3	10					
ACTION REQUIRED (SEE CODE BELOW):	a	11					
PRESSURIZATION							
DATE:	9 Dec. 70	12					
REASON (SEE CODE BELOW):	EFIR 48	13					
FORR NO:	KSC-70-XX	14					
MEASURED TEMPERATURE (°F):	73°	15					
PRESSURIZED TO (PSIG):	25.2	16					

REASONS:

1. Scheduled activity
2. EFIR or ECP action. (Enter No.)
3. To permit accessibility.
4. Storage requirement.
5. Repressurization required.
6. Vented in error.
7. Following corrective action.
8. Other ______________

ACTION:

a. No action required
b. Repressurize.
c. Leak-test. (Enter date and results).
d. Other ______________

I. GENERAL INSTRUCTIONS.

Entries must be made in the ECA, primary FI package, auxiliary FI package, and SIC pressurization records whenever tests are accomplished that require pressure monitoring or repressurization of the assemblies or cables.

NOTE

- If not included in the log book, a blank form must be inserted at the end of the Inspection Record section.
- If an ECA, primary or auxiliary FI package, or a SIC is replaced, a new form must be inserted at the end of the Inspection Record section and new entries recorded for the new component.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

NOTE

Step 1 is applicable to Spark Cable Pressurization Record only.

❶ CABLE IDENTITY - Enter identification of SIC being tested, such as NO. 1 ASI (G1), NO. 2 ASI (G2), NO. 1 GG (G3), or NO. 2 GG (G4).

NOTE

Steps 2 through 16 are identical for the ECA, primary FI package assembly, auxiliary FI package assembly, and SIC records.

❷ P/N - Enter part number of unit being tested.

Figure 3-94. Electrical Control Assembly, Primary and Auxiliary Flight Instrumentation Packages, and Spark Igniter Cable Pressurization Records (Typical) (Sheet 1 of 2)

3. S/N - Enter serial number of unit being tested.

4. DATE - Enter date pressure is monitored.

5. REASON - Enter reason for monitoring pressure in component (use code on bottom of form).

6. FORR NO. - Enter number of FORR used to perform monitoring task.

7. MONTHS SINCE LAST MONITORED OR PRESSURIZED - Enter time in months since component was last monitored or pressurized.

8. MEASURED TEMPERATURE (°F) - Enter measured hardware temperature (in Fahrenheit) at time component pressure is monitored.

9. MEASURED PRESSURE (PSIG) - Enter pressure monitored (gage reading) in component.

10. PRESSURE CORRECTED TO 70° F (PSIG) - Enter pressure obtained after correcting gage reading to 70° F.

11. ACTION REQUIRED - Enter action required after measuring pressure (use code on bottom of form).

12. DATE - Enter date component is pressurized.

13. REASON - Enter reason for pressurizing component (use code on bottom of form).

14. FORR NO. - Enter number of FORR used to perform pressurizing task.

15. MEASURED TEMPERATURE (°F) - Enter measured hardware temperature (in Fahrenheit) at time component is pressurized.

16. PRESSURIZED TO (PSIG) - Enter pressure remaining in component at completion of pressurizing task.

Figure 3-94. Electrical Control Assembly, Primary and Auxiliary Flight Instrumentation Packages, and Spark Igniter Cable Pressurization Records (Typical) (Sheet 2 of 2)

INSPECTION RECORD

MODEL J-2

ENGINE S/N J-2XXX

1 TYPE OF INSPECTION	2 RESULTS	3 LOCATION	4 DATE	5 INSPECTION	
				CON-TRACTOR	GOVERN-MENT
EFIR J2-5C Inspection of ASI LOX Line and OTBV and MFV Control Lines	Accomplished	RD-MTF	4 Oct 67		DNA
Receiving Inspection	Accomplished per TPS-C331-001 and FORR J2-MT-68-460 Ref TPS-ME31-030 and FORR J2-MT-68-470 for list of discrepancies	RD-MTF	21 May 68		DNA
Final Visual Prelaunch Inspection of SII-X Engines	Accomplished on FORR J2-MTF-68-470 and TPS-ME31-030 with 87 dicrepancies noted. (Refer to Discrepancy Record for major and open items.)	RD-MTF	10 Jun 68		DNA
Surveillance of DOP-MAI-E0221-J2 Engine Interim Firing and Function Check	Accomplished satisfactorily on FORR J2-MT-68-494	RD-MTF	13 Jun 68		DNA

I. GENERAL INSTRUCTIONS.

Entries must be made in the Inspection Record whenever scheduled, unscheduled, or special inspection tasks are accomplished.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

1 TYPE OF INSPECTION - Enter name or description of inspection authorized.

2 RESULTS - Enter brief description of results of inspection. Indicate Field Operation Requirement and Record (FORR) number, if applicable. Indicate discrepancies in Discrepancy Record (figure 3-90) when applicable.

3 LOCATION - Enter designation of facility where inspection occurs.

4 DATE - Enter date inspection is conducted.

5 INSPECTION - Enter stamp of Contractor representative making entries. Enter DNA in remaining Inspection column.

III. OTHER LOG BOOK FORMS THAT ARE (OR MAY BE) AFFECTED.

A. DISCREPANCY RECORD - If a discrepancy is noted during inspection that requires Unsatisfactory Condition Report (UCR) or material review type action, enter discrepancy on Discrepancy Record form. (See figure 3-90.)

B. SPECIAL NOTES AND COMMENTS - If unusual conditions or events of interest occur during inspection task, make an entry on Special Notes and Comments form (figure 3-96) when no other provisions are available for such entries.

C. POST-DELIVERY SERIALIZED COMPONENT REPLACEMENT RECORD. If a special inspection (EFIR) requires replacement of a serialized component listed in Rocketdyne Configuration Report R-5788, make entries in Post-Delivery Serialized Component Replacement Record. (See figure 3-87.)

D. POST-DELIVERY ORIFICE REPLACEMENT RECORD. If a special inspection (EFIR) requires replacement of an orifice, make entries in Post-Delivery Orifice Replacement Record. (See figure 3-89.)

Figure 3-95. Inspection Record

SPECIAL NOTES (1) AND COMMENTS

MODEL J-2 ENGINE S/N J-2XXX

J-2 Rocket Engine Part No. 103826, S/N J-2XXX, is installed in the General Assembly Stage, V7-00000X-XXX, S-II-X, Serial No. X, Position No. 3.

3 July 1968, 11:20 A.M.
J. R. Norman

Installation of desiccant was verified and humidity indicators were inspected per Process Specification HA0616-032 during engine storage at Downey.

15 July 1968, 3:30 P.M.
S. T. Koch

I. GENERAL INSTRUCTIONS.

Entries must be made on the Special Notes and Comments form whenever unusual conditions exist or events occur that are of interest regarding engine performance, tests, maintenance, status, etc for which no provisions are made elsewhere in the log book.

II. DETAILED INSTRUCTIONS.

Complete form as follows:

(1) Enter description of conditions or events providing sufficient details or so that like conditions or events may be recognized and analyzed, including date, time, and name of individuals observing and recording events and conditions.

Figure 3-96. Special Notes and Comments

MANUAL DATA SUPPLEMENTS

Manual Data Supplements are issued from time to time to communicate important and urgent information concerning the equipment covered in this manual. These supplements bear an identifying number and should be filed in this Appendix.

Manual Data Supplements directly affect the data in this manual and will be incorporated into this manual during a future updating effort.

A Manual Data Supplement Record is issued periodically to indicate the status of supplement issued for this manual. The status of each supplement is indicated in the "Supplement Status" column. For active supplements, no status is entered. For incorporated supplements, "Incorporated" is entered.

Upon receipt of a Manual Data Supplement, make an appropriate reference to the supplement in the margin next to the data supplemented, and enter the number, date, and subject matter of the supplement on the Manual Data Supplement Record.

MANUAL DATA SUPPLEMENT RECORD

This Manual Data Supplement Record indicates the status of supplements issued for Technical Manual R-3825-1B. Supplements that have been incorporated into this manual shall be removed from the Appendix and destroyed.

Supplement Number	Dated	Description	Supplement Status
R-3825-1B-1	21 March 1967	Changes engine installing and removing procedure to make sure engine vertical installer has same ground potential as facility.	Incorporated
R-3825-1B-2	24 March 1967	Changes start tank fill procedure to correct a step reference.	Incorporated
R-3825-1B-3	15 June 1967	Adds requirement to record all actuations and deactuations of helium regulator and pressure level of each operation, in Engine Log Book.	Canceled
R-3825-1B-4	25 April 1967	Adds procedure for installing and removing Thrust Chamber Throat Plug Kit G3120MD3.	Incorporated
R-3825-1B-5	25 April 1967	Adds resistance test of ignition detector probe.	Incorporated
R-3825-1B-6	21 July 1967	Adds procedure for inspecting fuel inlet duct bellows for distorted convolutions on stage-installed engines.	Incorporated
R-3825-1B-7	18 August 1967	Changes STDV closing time on engines incorporating MD275 change.	Incorporated
R-3825-1B-8	31 October 1967	Adds requirement to repeat the prelaunch helium mass-loss test if the helium high-pressure relief valve is actuated after performing the test.	Incorporated

Supplement Number	Dated	Description	Supplement Status
R-3825-1B-18	11 November 1968	Adds a requirement to monitor helium regulator outlet pressure (NN2) when regulator is operated with helium tank pressurized to 550 psia or greater; adds a requirement to inspect seals of caps removed from pressurizing valves on ECA, F1 packages, and spark igniter cables and to replace caps if seals are unsatisfactory; adds a leak test of spark plug tips during leak test of spark igniter cables disconnected from ECA; and replaces existing test procedure with a new procedure for reverse-leak-testing oxidizer turbine seal purge check valve and leak-testing oxidizer turbopump primary seal drain line, including a procedure for operating intermediate seal purge during leak tests to prevent backflow and possible contamination of helium regulator.	Incorporated
R-3825-1B-19	12 November 1968	Adds procedure for resistance-to-ground testing of electrical system.	Superseded by R-3825-1B-26
R-3825-1B-20	13 November 1968	Changes engine drying requirements and procedures.	Superseded by R-3825-1B-22
R-3825-1B-21	11 December 1968	Adds a requirement to inspect inlet duct alinement marks; adds procedures to measure MOV, MFV, and OTBV shaft seal leakage; deletes use of a mercury thermometer for measuring ambient temperature; and adds a requirement to enter spark igniter cable pressure in Engine Log Book.	Incorporated
R-3825-1B-22	20 December 1968	Changes engine drying requirements and procedures.	Incorporated
R-3825-1B-23	12 December 1968	Changes closing time for oxidizer and fuel bleed valves.	Incorporated
R-3825-1B-24	30 January 1969	Changes fuel turbine seal maximum allowable leakage.	Incorporated
R-3825-1B-25	12 January 1969	Adds procedure for using tape to seal the the thrust chamber throat plug.	Incorporated
R-3825-1B-26	16 January 1969	Changes resistance-to-ground test, and adds resistance test of ignition-phase control valve, mainstage control valve, and STDV control valve.	Superseded by R-3825-1B-35

Supplement Number	Dated	Description	Supplement Status
R-3825-1B-9	26 January 1968	Changes thrust chamber prechill temperature requirements.	Incorporated
R-3825-1B-10	5 February 1968	Changes prelaunch engine sequence test requirements.	Incorporated
R-3825-1B-11	5 March 1968	Adds requirement to remove protective closures from unused electrical connectors prior to launch; changes pressure for actuating start tank vent-and-relief valve; and changes time requirements to within 6 months prior to launch during prelaunch check at KSC for measuring pressure in ECA, primary, and auxiliary FI packages, for leak-testing the STDV swing gate and for pressure-decay-testing mainstage OK pressure switches.	Incorporated
R-3825-1B-12	11 March 1968	Adds requirement to clean ignition detector probe housing in ASI before installing a new probe, and adds instructions for reaming probe housing if resistance or binding is encountered during probe installation.	Incorporated
R-3825-1B-13	8 April 1968	Changes procedures to use spark igniter cable pressurization toolkit 9025425-21 provided by ECP J2-610.	Incorporated
R-3825-1B-14	26 March 1968	Changes pressure requirements for pressurizing engine helium tank during engine leak and function testing from 225-250 psig to 600 to 1,600 psig.	Incorporated
R-3825-1B-15	12 June 1968	Changes start system and thrust chamber test.	Incorporated
R-3825-1B-16	6 August 1968	Adds caution against energizing ignition detection simulation circuit after ignition-complete indication has been obtained.	Incorporated
R-3825-1B-17	16 August 1968	Changes flight instrumentation pressure transducer test voltage reading tolerances.	Incorporated

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R-3825-1B-27	16 January 1969	Adds procedure for isolating leakage when testing fast-shutdown valve diaphragm.	Incorporated
R-3825-1B-28	28 March 1969	Changes pressure transducer field checkout requirements to allow readout values within ±9 percent of full scale about the theoretical curve 0-5 vdc.	Incorporated
R-3825-1B-29	15 April 1969	Changes PU valve position requirement for engine start in flight from ±2 degrees to ±5 degrees, and deletes figures 3-1 and 3-2.	Incorporated
R-3825-1B-30	2 May 1969	Changes inspection requirements for installed electrical connectors, and adds constraint on retorque of connectors.	Incorporated
R-3825-1B-31	22 May 1969	Changes gimbaling limitation data to express in terms of percent of design life expended per cycle of gimbal angular excursion.	Incorporated
R-3825-1B-32	16 May 1969	Establishes a minimum diffuser coolant pressure requirement that must be observed during mainstage operation.	Incorporated
R-3825-1B-33	23 May 1969	Adds oxidizer turbopump primary seal drain line burst diaphragm test.	Incorporated
R-3825-1B-34	27 May 1969	Adds requirement to remove tape and protective film from in-place tube welds prior to leak testing.	Incorporated
R-3825-1B-35	28 May 1969	Deletes constraint requiring resistance testing of four-way control valves prior to performing electrical system resistance-to-ground test, deletes 120-day (prior to launch) constraint for performance of electrical system resistance-to-ground test, and deletes requirement to repeat electrical system resistance-to-ground test after an engine electrical control power connector has been disturbed.	Incorporated
R-3825-1B-36	10 June 1969	Changes prelaunch engine hardwire sequence test requirement from 75 days prior to launch to high bay, adds requirement to use ASI chamber blocking device when performing spark igniter test, and adds an isolation procedure to be used when fuel turbopump primary seal drain check valve minimum flow is not obtained.	Incorporated

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R-3825-1B-74	24 July 1972	Superseded Manual Data Supplement No. R-3825-1B-72, dated 17 July 1972 to delete the 15 day spark igniter cable pressure monitor requirement from the cable pressurizing procedure.	Incorporated
R-3825-1B-75	1 August 1972	Changes requirement for removal of the oxidizer turbopump primary seal stage overboard drain line closure.	Incorporated
R-3825-1B-76	11 October 1972	Adds requirement to perform engine sequence test during CDDT.	Incorporated
R-3825-1B-77	17 January 1973	Adds engine operational requirements for the purge control valve and the oxidizer turbopump primary seal drain line burst diaphragm assembly.	Incorporated
R-3825-1B-78	23 January 1973	Changes the thrust chamber pre-chill (conditioning) requirements.	Incorporated
R-3825-1B-79	26 February 1973	Adds an engine helium supply decay test for SII stage engines and requirements for valve timing and sequence test cycling for engines with various fast shutdown valves installed.	Incorporated
R-3825-1B-80	6 April 1973	Adds a requirement that two persons each inspect and record inspection of the connection of each joint that cannot be leak tested. Details of a joint inspection are also given.	Incorporated
R-3825-1B-81	6 April 1973	Changes the thrust chamber pre-chill (conditioning) requirements.	Incorporated
R-3825-1B-82	12 April 1973	Changes the duration of time for monitoring pin movement while leak testing the burst diaphragm test fixture.	Incorporated
R-3825-1B-83	16 April 1973	Changes leak-test compound (MIL-L-25567) to leak-test compound (MSFC-SPEC-384).	Incorporated
R-3825-1B-84	12 June 1973	Changes the ECA and flight instrumentation package pressure limits.	Incorporated

Supplement Number	Dated	Description	Supplement Status
R-3825-1B-37	10 June 1969	Changes pneumatic system leak test requirements to permit waiving the requirement to leak-test individual flange and weld joints on both restart-and nonrestart-mission engines. This supplement also changes reference point for bleed valve and ASI valve timing.	Incorporated
R-3825-1B-38	14 July 1969	Adds pneumatic accumulator system pressure-decay test to engine pneumatic system helium usage test.	Superseded by R-3825-1B-39
R-3825-1B-39	29 July 1969	Adds pneumatic accumulator system pressure-decay test to engine pneumatic system helium usage test.	Incorporated
R-3825-1B-40	3 October 1969	Changes accuracy requirement of resistance measuring device for testing ignition detector probe.	Incorporated
R-3825-1B-41	3 October 1969	Changes oxidizer turbopump primary seal drain line burst diaphragm leak test.	Incorporated
R-3825-1B-42	25 November 1969	Adds start tank maximum pressurization rate requirements.	Incorporated
R-3825-1B-43	26 November 1969	Adds timing information for STDV 304386 when installed as a spares replacement.	Incorporated
R-3825-1B-44	22 January 1970	Changes procedural sequence for installing and removing engine exhaust system test plates.	Incorporated
R-3825-1B-45	30 January 1970	Adds procedure for using resistance test selector, deletes 6-month prior-to-launch requirement for leak-testing STDV swing gate and for pressure-decay testing mainstage OK pressure switches, and changes MOV timing requirements.	Incorporated
R-3825-1B-46	17 March 1970	Adds requirement to inspect flange joint downstream of GG oxidizer purge check valve for proper length bolts.	Incorporated
R-3825-1B-47	11 June 1970	Changes temperature compensated MOV timing requirements to require correcting recorded opening time when MOV temperature is below 70° F, and deletes the requirement to maintain a vacuum for 30 seconds when leak-testing the oxidizer turbopump primary seal drain line burst diaphragm.	Incorporated

Supplement Number	Dated	Description	Supplement Status
R-3825-1B-48	3 August 1970	Adds helium supply system pressure decay test which is to be performed during CDDT and launch countdown; changes pressure requirement for leak testing propellant interface connections; changes allowable pressure decay rate for helium supply system; changes torque value for thrust chamber throat plug burst diaphragm; and adds accuracy requirement for vacuum gages used during engine drying.	Incorporated
R-3825-1B-49	11 August 1970	Adds a function test of the mixture ratio control valve and changes the engine sequence test to include a mixture ratio control valve timing check.	Superseded by R-3825-1B-52
R-3825-1B-50	24 August 1970	Adds the requirement to resistance-test all (7) valve control solenoids on the engine, establishes temperature-compensated limits for pin A to B resistance values, and make it mandatory that the test be performed as a pre-static test and VAB checkout activity.	Superseded by R-3825-1B-53
R-3825-1B-51	15 September 1970	Adds a cryogenic actuation test and a post installation function test of the mixture ratio control valve and changes the engine sequence (hardwire) and helium usage sequence tests to include mixture ratio control valve requirements.	Superseded by R-3825-1B-52
R-3825-1B-52	7 October 1970	Adds requirements and procedures for leak-and function-testing the MRCV and for drying the MRCV linkage cavity, and changes film-cooled diffuser operating limits.	Incorporated
R-3825-1B-53	6 October 1970	Changes resistance test requirements for the start tank emergency vent valve and the MRCV.	Incorporated
R-3825-1B-54	19 November 1970	Changes spark igniter cables, FI packages, and ECA pressure-measuring and pressurization requirements and procedures.	Incorporated
R-3825-1B-55	3 December 1970	Changes the allowable pressure decay rate for the helium supply system; adds an oxidizer turbopump intermediate seal purge flow correction factor to the helium usage test, adds the use of a special fitting for drying the MRCV, corrects the inlet duct torsional bellows heater resistance test, and changes MRCV shaft seal leak-test criteria.	Incorporated

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R-3825-1B-56	28 April 1971	Changes hardwire sequence test to require performing test within 120 days before launch and to require running 12 cycles.	Incorporated
R-3825-1B-57	1 July 1971	Changes torque values on the pressurizing valve used on the ECA, FI packages, and spark igniter cables and deletes the requirement to leak-test the metal-to-metal seat and valve core with leak-test compound.	Incorporated
R-3825-1B-58	17 September 1971	Changes spark igniter cable leak-test procedure to add requirement to inject helium under the RTV tape sheathing and adds a statement that engine handling equipment must be operated by qualified personnel.	Incorporated
R-3825-1B-59	22 September 1971	Corrects torque value for the GG oxidizer purge line flange bolts.	Incorporated
R-3825-1B-60	29 October 1971	Adds procedure for calculating and recording the J-2 start tank pressure cycle life based on fracture mechanics analysis.	Incorporated
R-3825-1B-61	18 October 1971	Changes the pressurizing valve core replacement procedure and increase the initial spark igniter cable pressure limit.	Superseded by R-3825-1B-64
R-3825-1B-62	3 November 1971	Changes replacement requirements for engine vent port check valves.	Incorporated
R-3825-1B-63	16 December 1971	Changes inspection procedures to clarify interpretation of clearance requirements of customer connect fluid lines and adds a detailed list of engine components that have gimbaling limitations.	Incorporated
R-3825-1B-64	17 December 1971	Changes pressurizing valve leak test requirements, and supersedes Manual Data Supplement No. R-3825-1B-61, dated 18 October 1971.	Incorporated
R-3825-1B-65	7 January 1972	Adds electrical power application constraints when performing tests requiring the engine to be in the components test mode.	Incorporated

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R-3825-1B-84	12 June 1973	Changes the ECA and flight instrumentation package pressure limits.	Incorporated
R-3825-1B-85	14 August 1973	Adds ground support equipment, special tools, and material usage constraints.	Incorporated
R-3825-1B-86	24 August 1973	Corrects part number of test plate installed between STDV drain line and thrust chamber exhaust manifold.	Superseded by R-3825-1B-100

Supplement Number	Dated	Description	Supplement Status
R-3825-1B-87	5 November 1973	Corrects an instrumentation tap identification number, corrects engine configuration for heat exchanger outlet temperature measurements, corrects the part number of the test plate installed between the STDV drain line and thrust chamber manifold during leak-testing oxidizer feed system, corrects a component identification in the engine sequence testing procedure, and incorporates MD380 and MD381 changes in engine sequence control timer operating values.	Superseded by R-3825-1B-100
R-3825-1B-88	9 November 1973	Adds a requirement to replace the heat sink compound between thrust chamber temperature transducer and transducer mounting pad within 6 months before launch.	Incorporated
R-3825-1B-89	27 November 1973	Adds a requirement to inspect auxiliary and primary flight instrumentation package transducers for stress corrosion.	Superseded by R-3825-1B-91
R-3825-1B-90	5 December 1973	Adds a procedure for inspecting primary and auxiliary flight instrumentation package transducers for stress corrosion.	Superseded by R-3825-1B-95
R-3825-1B-91	4 January 1974	Specifies that the maximum time between stress corrosion inspection of auxiliary and primary flight instrumentation package transducers must not exceed 90 days.	Superseded by R-3825-1B-94
R-3825-1B-92	9 January 1974	Adds a requirement to verify orifice installation and requirements for reinstallation of orifice tag.	Incorporated
R-3825-1B-93	16 January 1974	Adds a requirement to use adapter 908133 when measuring flow downstream of the oxidizer turbopump intermediate seal purge check valve.	Incorporated
R-3825-1B-94	11 February 1974	Specifies the time intervals for performing stress corrosion inspection of auxiliary and primary flight instrumentation package transducers.	Superseded by R-3825-1B-95

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R-3825-1B-95	2 March 1974	Specifies the time intervals for performing stress corrosion inspection of auxiliary and primary flight instrumentation package transducers and base of mainstage OK pressure switches and adds procedures for performing the inspections.	Incorporated
R-3825-1B-96	4 April 1974	Permits removal of drain lines closures for engines stored in accordance with requirements of MSFC-STD-496.	Incorporated
R-3825-1B-97	6 August 1974	Corrects an MD number and adds installation and removal requirements for helium high-pressure relief valve dust cover for engines incorporating MD362 change.	Incorporated
R-3825-1B-98	30 August 1974	Incorporates new test kits EWR225308, EWR225309, and EWR230004, and changes test plate kits 9016701 and 9016710 to 9016701-11 and 9016710-11 kits by adding attaching bolts, nuts, and washers in kits.	Superseded by R-3825-1B-100
R-3825-1B-99	12 September 1974	Adds redundant timer adapter EWR220289 which is used during single engine sequence tests so that ECA timer traces will be recorded on the oscillograph and adds requirement to check MOV opening times after single engine sequence tests have been completed.	Superseded by R-3825-1B-100
R-3825-1B-100	30 September 1974	Adds new leak test kit EWR225310, changes test plate kit 9025400 to 9025400-11, and incorporates changes and corrections to supplements R-3825-1B-98 and R-3825-1B-99.	Incorporated
R-3825-1B-101	24 January 1975	Corrects electrical cable part number when connecting Electrical Checkout Console G1037 to engine when drying uninstalled engine.	Incorporated